A HISTORY OF THE INTRODUCTION OF GAS LIGHTING

BY

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WILLIAM MURDOCH.

From the Portrait in the Edinburgh Art Gallery. Kindly photographed by Mr. W. R. Herring.

A HISTORY OF THE INTRODUCTION OF GAS LIGHTING

BY

CHARLES HUNT, M.INST.C.E.

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AUTHOR OF "GAS LIGHTING," WHICH FORMS THE THIRD VOLUME OF
GROVES AND THORPE'S "CHEMICAL TECHNOLOGY"

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PREFACE.

THIS work is an endeavour to trace the circumstances and events which led up to the establishment of gas lighting. It necessarily contains much that has been already—and better—told by others; but it also contains matter that is believed to be new. In its production I have been greatly assisted by many friends both abroad and at home; my thanks being especially due to Mr. George Tangye for kindly placing at my disposal his collection of Murdoch papers and drawings, which were preserved by him at the winding-up of the once famous establishment of Boulton & Watt; Mr. R. B. Prosser, for an original handbill of Winsor's, a reprint of Murdoch's letter to Parliament, and other matter; and the Directors and chief officials of the Gas Light and Coke Company, for permission to copy Winsor's portrait, and the loan of various documents. I have also much pleasure in acknowledging my indebtedness to Miss Murdoch, the Post-mistress at Lugar, for valuable information as to the locality of Murdoch's birthplace.

CHAS. HUNT.

June, 1907.

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A HISTORY OF THE INTRODUCTION OF GAS LIGHTING.

CHAPTER I.

EARLY RECORDS.

TO the ordinary observer the deterrent effect of periods of war or revolution upon the intellectual growth and development of a nation is not always apparent. He may, indeed, find some justification for the belief that, occasionally, they actually stimulate in this direction. Milton, for example, was a product of a revolutionary epoch ; and although it is unfortunately true that Lavoisier fell a victim to the violence of a Republic that had " no need of savants," yet those years of storm and strife, which ended so disastrously for his country, are not the least brilliant in the annals of scientific achievement. The intellectual forces of humanity are indeed inextinguishable.

This reflection may not be considered as wholly out of place in connection with our subject, seeing that it was during such time of storm and strife, and while distracted by issues of life and death, that the two leading nations of Europe each gave birth, independently of the other, to an industry which in its development has increased the comfort of living, advanced civilization, and given employment, direct and indirect, to huge industrial armies. With this industry are inseparably associated the names of William Murdoch and Philippe Lebon, to whom we are indebted—although in different degrees—for the introduction of the art of gas lighting.

Long before their time the phenomenon which Murdoch was the first to turn to useful account had engaged the attention of philosophers, and formed the subject of many experiments. For an infinitely longer period mankind had been familiar with inflammable gas escaping from the earth, within which it is formed in connection with deposits of coal or petroleum and also of rock-salt. The existence of burning fountains has long been on record. " The eternal fires of Baku, on the shores of the Caspian Sea, which have been known as burning from remote ages, are due to gaseous hydro-carbons issuing from and through petroleum deposits. In the province of Szechuan, in China, gas is obtained from beds of rock-salt at a depth of 1500 or 1600 feet; being brought to the surface, it is conveyed in bamboo tubes, and used for lighting as well as for evaporating brine; and it is asserted that the Chinese used this naturally evolved gas as an illuminant long before gas lighting was introduced among European nations. At a salt mine in the comitat of Marmaro, in Hungary, gas is obtained at a depth of about 120 feet, and is used for illuminating the works of the mine."[1] The "eternal fires," which are here referred to, "rendered Baku a favourite resort of the fire-worshippers, who for long maintained their temples in the district; but though the natural phenomena display themselves as abundantly as ever, they are now almost entirely deserted by devotees."[2] The district is now widely known for its enormous yield of petroleum, the products of which are used extensively for gas-making and other purposes. Plutarch relates how Alexander the Great, during his conquest of Asia, met in the district of Ecbatana with a gulf of fire, which streamed continually, as from an inexhaustible source. In this country similar exhalations have been observed; and they still continue to be met with. The first of which any record exists occurred in the seventeenth century at a spring of water near Wigan; and its inflammability was thought to be due to the water which issued from it. The puzzling phenomenon was, however, investigated by one Thomas Shirley, whose account of it as published in the *Philosophical Transactions for* 1667 (vol. ii. pp. 482–4) is as follows:

The Description of a Well and Earth in Lancashire, taking Fire by a Candle approached to it.

This was imparted by that ingenious and worthy gentleman, Thomas Shirley, Esq., an eye-witness of the thing, now to be related in his own words, namely:

"About the late end of February, 1659, returning from a journey to my house in Wigan, I was entertained with the relation of an odd Spring, situated in one Mr. Hawkley's Ground (if I mistake not) about a mile from the Town, in that Road which leads to Warrington and Chester.

"The people of this Town did confidently affirm, that the Water of this Spring did burn like Oyle; into which Error they suffered themselves to fall for want of a due examination of the following particulars.

"For when we came to the said Spring (being five or six in company together) and applying a lighted Candle to the surface of the Water; 'tis true, there was suddenly a large flame produced, which burnt vigorously; at the sight of which they all began to laugh at me for denying, what they had positively asserted; But I, who did not think myself confuted by a laughter grounded upon inadvertency, began to examine what I saw; and observing, that this Spring had its eruption at the foot of a Tree, growing on the top of a neighbouring Bank, the Water of which Spring filled a Ditch that was there, and cover'd the burning place lately mention'd ; I then applyed the lighted Candle to divers parts of the Water, contain'd in the said Ditch, and found as I expected, that upon the touch of the Candle and the Water, the Flame was extinct.

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[1] *Encyclopædia Britannica*, 9th edition, vol. x. pp. 87–88.

[2] *Ibid.* vol. iii. p. 258.

" Again, having taken up a dishful of Water at the flaming place, and held the lighted Candle to it, it went out. Yet I observed that the Water at the burning place did boyle, and heave like Water in a Pot upon the Fire, though my hand put into it perceived it not so much as warm.

" This boyling I conceived to proceed from the Eruption of some bituminous or sulphurous Fumes ; considering, this place was not above 30 or 40 yards distant from the mouth of a Coal-pit there. And indeed Wigan, Ashton, and the whole Country, for many miles compass, is underlaid with coal. Then applying my hand to the surface of the Burning place of the Water, I found a strong breath, as it were a Wind, to bear against my hand.

" Then I caused a Dam to be made, and thereby hindering the recourse of fresh water to the Burning place ; I caused that which was already there to be drained away ; and then applying the burning Candle to the surface of the dry Earth at the same point, where the Water burned before ; the Fumes took fire, and burned very bright and vigorous. The Cone of the Flame ascended a foot and a half from the Superficies of the Earth. The Basis of it was of the Compass of a Man's hat about the brims. I then caused a Bucket-full of Water to be poured on the fire, by which it was presently quenched, as well as my companions' laughter was stopped, who then began to think, the Water did not burn.

" I did not perceive the Flame to be discolour'd, like that of sulphureous Bodies, nor to have any manifest Scent with it. The Fumes, when they broke out of the Earth, and prest against my hand, were not, to the best of my remembrance, at all hot."

A similar, but even more remarkable effect was observed nearly 200 years later—namely, in 1846—when the surface of the River Wear, near Framwellgate Bridge, was covered with bubbles caused by an exhalation of gas from the bed of the river. These bubbles were readily ignited, and afforded the spectacle of the river apparently on fire. Again in 1851, when boring for water on Chat Moss, between Manchester and Liverpool, gas was, by means of a pipe 10 or 12 inches in diameter, conducted above the forest trees, and there burned with a flame 8 to 10 feet long. During the last few years borings have been made at Heathfield in Sussex, with the object of applying this gas commercially ; while, still more recently, a supply of natural gas was discovered at Bradford, when boring for water. This was met with at a depth of 900 feet, and it is stated that the quality of the gas was much superior to that of coal gas, and burned with a brilliant flame several feet in height, on a light being applied. But by far the most remarkable and important of these developments has occurred in the oil regions of North America, where wells have been sunk to a depth of many hundreds of feet, from which the gas issues with a natural force equal in some cases to 800 lbs. per square inch. The existence of this gas is said to date from long before the appearance of the white man on the American Continent, and a gas well was struck while boring for salt at Olive, Noble County, Ohio, in 1814. It is, however, not much more than twenty years ago that extensive use began to be made of this natural product, by the laying of pipe lines to supply the manufactories of Pittsburg. In 1886 and 1887 great developments took place, such enormous quantities of this gas being discovered as to create the impression that the supply was practically inexhaustible. Almost incredible waste was the result; gas escaping from defective joints in the pipe lines was set fire to, illuminating the country for many miles, and almost turning night into day. The climax was reached in 1888, when not less than 750,000,000,000 cubic feet of natural gas are believed to have been consumed and wasted. For this immense quantity only $22,630,000 were paid; which is at the average rate of about 3 cents per 1000 cubic feet.

For several years after 1888, the production of natural gas steadily diminished, until in 1895 and 1896 its annual value was only $13,000,000. From that time there has again been an increase both in value and quantity; a new production, chiefly in West Virginia, having more than made good the decline of the older fields.

The distribution of this gas at a cheap rate for industrial purposes has materially contributed to the prosperity which the manufactures of the United States have enjoyed for a considerable period. The value of this gas sold in 1902 was $30,867,863,[1] being greater than that of any previous year. This at an average price of 15 cents per 1000 cubic feet, represents a production of 205,785,753,000 cubic feet, or the equivalent of about 9,799,321 tons of coal, on the basis of 21,000 cubic feet being equal in heating value to one ton. This quantity of gas was distributed to great distances through 24,850 miles of mains, to no fewer than 8094 industrial establishments, including iron, steel, and glass works; besides 505,583 consumers for domestic purposes. It is asserted that not less than 3,580,000 individuals are thus supplied with light and fuel. One of its latest applications is that to the city of Cleveland in Ohio, for the supply to which for heating purposes at 30 cents per 1000 cubic feet, in competition with the local gas company, about 300 miles of mains have been laid.

This inflammable gas is the "fire damp," so much dreaded by the miner, of which one of the first recorded accounts is that by Mr. Jessop, which was communicated to the Royal Society in 1674, and appears in its *Transactions* for that year. Its occurrence is not entirely confined to coal mines, it being met with in ironstone, salt and lead mines. An explosion of it causes the equally dreaded "choke damp," consisting chiefly of carbonic acid, which results from its combustion.

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[1] In 1903 the value of this gas sold was $35,807,860; in 1904, $38,496,760; and in 1905, $41,562,855.

Of the composition of aeriform substances which—to use Lavoisier's definition—are separated from bodies either by means of fire, fermentation, or effervescence, the ancients appear to have known very little. Even down to the time of Paracelsus (1493–1541), these were distinguished by the generic title of "Spiritus Silvestris." Paracelsus, who was the first to discover that such substances could be produced artificially, believed their composition to be the same as atmospheric or "common" air. He obtained what we now know as hydrogen by the solution of iron by sulphuric acid; but attached no importance to his discovery, nor does he seem to have been aware of the inflammability of the gas which he produced. This was observed some years later by Turquet de Mayerne, and afterwards (1672) by Boyle. Paracelsus, it may be mentioned, was the first physician to adopt chemical pharmacy, and was also the first public lecturer on medicine and chemistry.

Van Helmont (1577–1644) seems to have been the first to inquire into the nature of this "Spiritus Silvestris"; and this led him to conclude that it was different from atmospheric air, having a greater affinity with water, and probably consisting of water reduced to vapours. In his *Treatise de Flatibus*, he introduces the word "Gas," as to the origin of which he says: "But because of the water which is brought into a vapour by cold, is of another condition, than a vapour raised by heat; therefore by the Licence of a Paradox, for want of a name, I have called that vapour Gas, being not far severed from the Chaos of the Ancients. In the meantime it is sufficient for me to know, that Gas, is a far more subtile or fine thing than a vapour, mist or distilled Oylinesses, although as yet it be many times thicker than air. But Gas itself, materially taken, is water as yet masked with the ferment of composed Bodies."[1] Again: "Therefore the live coal, and generally whatsoever bodies do not immediately depart into water, nor yet are fixed, do necessarily belch forth a wild spirit or breath. Suppose thou, that of 62 pounds of Oaken Coal, one pound of ashes is composed. Therefore the 61 remaining pounds are the wild spirit which also being fixed, cannot depart, the vessel being shut.

"I call this Spirit, unknown hitherto, by the new name of Gas, which can neither be retained by Vessels, nor reduced into a visible body, unless the seed be first extinguished."[2]

Lavoisier was of opinion that Van Helmont derived this word "Gas" from the Dutch word Ghoast, which signifies "Spirit," and has its equivalent in the German word Geist (pronounced Gaistre), and also in the English word Ghost. On the other hand, Juncker, whose *Conspectus Chemiæ Theoretico-Practicæ* was first published in 1730, favours (p. 365) its derivation from the

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[1] Van Helmont's *Works*, p. 69. Translated by J. C., of Magdalen Hall, Oxon. London, 1664.

[2] *Ibid.* p. 106.

German word Gâscht or Gâst, signifying ferment, froth, yeast, or foam ; which seems as probable a conjecture as any. But whatever its origin, the suitability of the word " gas " has long been universally admitted, although some time was to elapse before it was recognized. The following definition of the word appears in Macquers' *Dictionnaire de Chymie*, published in Paris in 1676 (p. 550) :

" Gas. Les Chymistes ont donné ce nom aux parties volatiles invisibles qui émanent d'elles-mêmes de certains corps & que l'on ne peut retenir & recueillir, ou du moins que trés difficilement, & point pures. Ainsi, par exemple, les vapeurs meurtrieres qui s' exhalent du charbon lorsqu'il brûle, celle des matieres qui subissent la fermentation spiritueuses ou putride, la partie volatile des eaux minérales spiritueuses, l'esprit, recteur, même de certaines substances, telles que le muse, peuveut étre appellés le Gas de tous ces corps." The term, however, was not adopted in France until 1786, nor in England until a much later date. In Nicholson's *Dictionary of Chemistry*, published in London in 1795, appears (p. 344), the following :

" Gas. This term was first applied by Van Helmont, to denote the permanent elastic exhalations afforded in chemical processes. Dr. Priestley, whose extensive and successful researches into this department of natural philosophy have in the space of a few years produced a revolution in the science of chemistry, uses the word air as the generic term for permanently elastic fluids. Other chemical writers of great reputation have thought fit to revive Van Helmont's term, and confine the word air to the atmospheric fluid. The English Philosophers, however, have in general followed Dr. Priestley, and, as it seems altogether as simple, to add the word atmospherical, vital or respirable, to that air which is peculiarly adapted to the maintenance of life and combustion, as to denote it by any single peculiar term not used in the enunciation of other elastic fluids, we have also adopted the same rule."

In a subsequent edition, published in 1808, which is described as having been formed on the basis of the earlier Dictionary, " but is in effect an entirely new work . . . adapted to the present improved state of chemical science," the last sentence of the above quotation is omitted, and the definition of the term gas ends as follows : " As this " (the revival of Van Helmont's term) " has been found convenient, to prevent confusion of ideas, it is now generally adopted ; and we shall proceed to give an account here of these elastic fluids."

It appears from this that the word " gas " was only adopted in this country somewhere between 1795 and 1808, or more than 150 years after its invention by Van Helmont, and thus almost coincidently with the introduction of gas lighting. Its previous adoption in France, by Lavoisier and others, was in opposition to the views then expressed by English chemists.

Van Helmont distinguished between gases and vapours as being respectively permanent and condensable ; and he regarded flame as being produced by ignited vapours. He also attributed to the effluvium of gas, the fatal effects of the Grotto delle Cani, in the kingdom of Naples ; the suffocation

THE HON. ROBERT BOYLE, F.R.S. [*Emery Walker, Photo.*

From the Portrait by F. Kerseboom, in the National Portrait Gallery.

of workmen in mines; accidents occasioned by the vapour of charcoal; and that deleterious atmosphere which is breathed in cellars where spirituous liquors are in fermentation.

Boyle, in the latter half of the seventeenth century, distinguished between the effect of combustion and that of distillation. He repeated many of Van Helmont's experiments, and showed (1680) that "air" could be produced artificially. This artificial air, as he called it, he succeeded in collecting without mixture with atmospheric air.

Contemporaneously with Boyle occurs the first record of the actual distillation of coal and the collection of the resultant gas. This is in the form of a communication made to Boyle by Dr. Clayton, some time rector of Crofton at Wakefield, in Yorkshire. It was not published until some years afterwards, but, as Boyle died in 1691, must have been made during the latter half of the seventeenth century.[1] A copy appeared in the *Transactions of the Royal Society*, 1739–40, without any date attached to it. The original of this copy, now in the British Museum (additional MSS. 4437), was accompanied by a letter from the Bishop of Cork (Boyle's son), dated London, 23rd December 1740 (?), vouching for the description "as far as concerns the sincerity and faithfulness of my copying it from the original, which I found among my father's papers and in his own handwriting."

Having regard to the historical interest which attaches to this communication, it is here given in full.

AN EXPERIMENT CONCERNING THE *SPIRIT OF COALS*, INTER ALIA IN A LETTER TO THE HON. *MR. BOYLE* BY THE LATE REV. *JOHN CLAYTON*, D.D., COMMUNICATED BY THE RIGHT REV. FATHER IN GOD *ROBERT* LORD BISHOP OF *CORK* TO THE RIGHT HON. EARL OF EGMONT, F.R.S.

"Having seen a Ditch within two miles from *Wigan* in *Lancashire* wherein the water would seemingly burn like Brandy, the Flame of which was so fierce, that several strangers have boiled eggs over it, the People thereabouts indeed affirm that about 30 years ago it would have boiled a Piece of Beef; and that whereas much Rain formerly made it burn much fiercer, now after Rain it would scarce burn at all. It was after a long-continued Season of Rain that I came to see the Place, and make some Experiments, and found accordingly, that a lighted Paper, though it were waved all over the Ditch, the Water would not take Fire. I then hired a person to make a Dam in the Ditch and fling out the Water, in order to try whether the Steam which arose from the Ditch would then take fire, but found it would not. I still, however, pursued my Experiments, and made him dig deeper; and when he had dug about the Depth of half a yard, we found a Shelly Coal, and the

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[1] The year 1664 has been referred to as the date of this communication, but upon what authority the author has not been able to trace.

Candle being then put down into the Hole, the Air catched Fire, and continued burning.

" I observed that there had formerly been Coal-pits in the same Close of Ground ; and I then got some coal from one of the Pits nearest thereunto, which I distilled in a Retort in an open Fire. At first there came over only *Phlegm*, afterwards a black *Oil*, and then likewise a *Spirit* arose, which I could no ways condense, but it forced my Lute, or broke my Glasses. Once when it had forced the Lute, coming close thereto, in order to try to repair it, I observed that the Spirit which issued out caught fire at the Flame of the Candle, and continued burning with Violence as it issued out in a stream, which I blew out, and lighted again, alternately, for several times. I then had a mind to try if I could save any of this Spirit, in order to which I took a turbinated Receiver, and putting a Candle to the Pipe of the Receiver whilst the Spirit arose, I observed that it catched Flame, and continued burning at the End of the Pipe, though you could not discern what fed the flame ; I then blew it out, and lighted it again several times ; after which I fixed a Bladder, squeezed and void of Air, to the Pipe of the Receiver. The *Oil* and *Phlegm* descended into the Receiver, but the Spirit, first ascending, blew up the Bladder. I then filled a good many Bladders therewith, and might have filled an inconceivable Number more ; for the Spirit continued to rise for several Hours, and filled the Bladders almost as fast as a man could have blown them with his mouth, and yet the Quantity of Coal I distilled was inconsiderable.

" I kept this Spirit in the Bladders a considerable time, and endeavoured several days to condense it, but in vain. And when I had a mind to divert strangers or Friends, I have frequently taken one of these Bladders, and pricking a hole therein with a pin, and compressing gently the Bladder near the Flame of a Candle till it once took fire, it would then continue flaming till all the Spirit was compressed out of the Bladder ; which was the more surprising, because no one could discern any Difference between these Bladders and those which are filled with common Air.

" But then I found, that this Spirit must be kept in good thick Bladders, as in those of an Ox, or the like ; for if I filled Calves Bladders therewith, it would lose its inflammability in 24 Hours, though the Bladder became not relax at all." [1]

A few years before the publication of this account—namely, in 1727—had appeared Dr. Stephen Hales's *Vegetable Staticks, or an Essay towards a Natural History of Vegetation*, in which is recorded a series of interesting experiments—the first of the kind—undertaken for the purpose of determining " the quantity of air which arose from any body by distillation or fusion." These experiments, which had previously been communicated to the Royal Society, embraced a great variety of substances, one of which was Newcastle coal. The apparatus described and illustrated by the author as having been used by him in most of the experiments, consisted of an ordinary glass retort, which was placed over fire, and led downwards to a glass receiver open at the bottom, and resting in a basin or tub of water. The "air" as it became evolved from the substance distilled, was collected in the receiver, the water displaced in this being the measure of its quantity. For some of the experiments a musket barrel was substituted for the glass retort. This, heated at a smith's forge, was used in Experiment No. 67, of which he says: "By the same means also" (*i.e.* by distillation) "I found plenty of air might be obtained from *minerals.* Half a cubick inch, or 158 grains of *Newcastle Coal,* yielded 180 cubick inches of air, which arose very fast from the coal, especially when the yellowish fumes ascended. The weight of this air is 51 grains, which is nearly $\frac{1}{3}$rd the weight of the coals."

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[1] *Philosophical Transactions of the Royal Society*, vol. xli. part i. pp. 59–61.

Neumann, in 1759, stated that "forty-eight ounces (of the best sort of the Halle Pit-coal), distilled in a glass retort, with a fire gradually increased, yielded two ounces seven drams of phlegm; two ounces and one dram of a thin fluid oil; and one ounce of a thick tenacious, ponderous, pitchy oil, which stuck in the neck of the retort; the residuum weighed forty-one ounces seven drams."[1] There is not a word as to any gaseous products, the remainder of the description relating to the distilled liquors, which were the object of the experiment, and the *caput mortuum.*

Neumann, however, found that inflammable vapour, "made by pouring dilute vitriolic acid over iron, is permanent and elastic, and seems to have a great analogy to the inflammable damp in mines. It may be collected and preserved in bladders; which being applied to the mouth of the vessel, wherein the dissolution is made will soon be filled and distended by it. After keeping for several weeks, a little of the vapour, forced out near a candle, instantly took flame as at first."[2]

The first account we have of the distillation of coal for industrial purposes is that by De Gensanne, who from personal observation described[3] the method of coking coal as conducted at the ironworks belonging to the Prince of Nassau-Saarbrucken at Sultzbach. He says: "Within a shed built for the purpose several furnaces are arranged in line, and adjoining one another. Of these, three at least are being heated while the others are being cooled, When the coal is half roasted in the first three, the next three are kindled, and again when the process in these is half complete three more are fired. Since the roasting occupies three times 24 hours, by this means three furnaces are drawn every day, and at least nine furnaces are worked continuously to supply the works."

Figs. 1, 2, 3, 4, and 5 are reproductions from De Gensanne's work,

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[1] *The Chemical Works of Caspar Neumann, M.D.*, abridged and methodized by William Lewis, M.B., p. 245. London, 1759.

[2] *Ibid.* p. 70.

[3] *Traité de la Fonte des Mines par le feu du charbon de terre, &c.*, par M. De Gensanne, vol. i. p. 263 *et seq.* Paris, 1770.

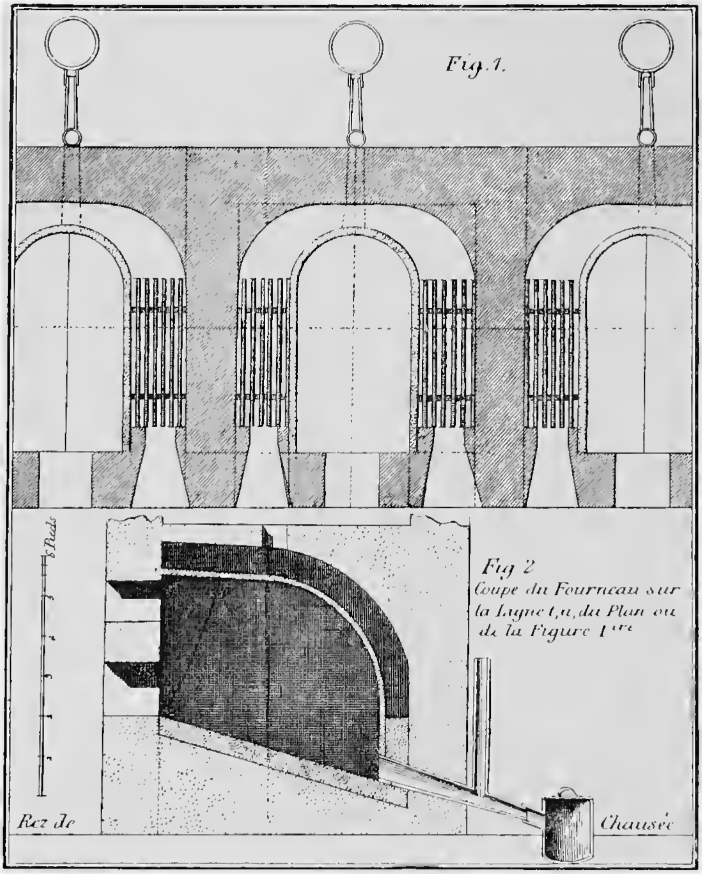
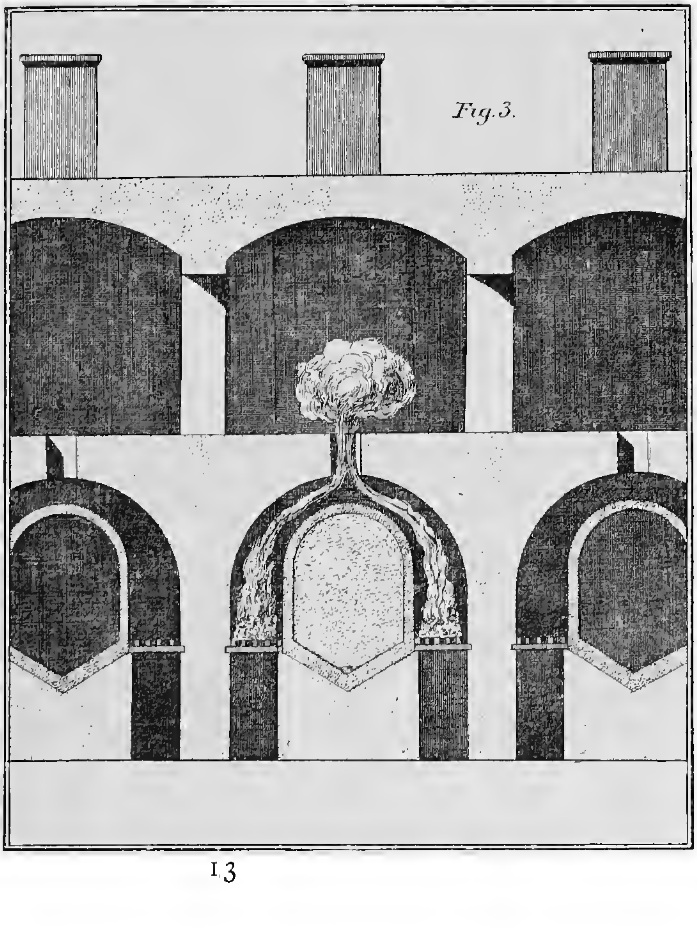


Fig. 1.
6 Pieds
Fig 2
Coupe du Fourneau sur la Ligne t,u, du Plan ou de la Figure 1re
Rez de
Chausée

of the illustrations of this furnace, which was in reality a gas retort—presumably the first ever constructed on a working scale—and the forerunner of the modern coke recovery oven. It consisted mainly of an arched chamber of solid brickwork closed at the back, and with doors in the front for firing. This chamber was about 6 feet long, and measured about 4 ft. 6 in. from the line of the firebars to the top of the arch. Running the whole length were two firegrates about 14 inches in width, and between these the floor of the chamber was raised to form a foundation upon which an internal sealed firebrick chamber rested, which latter the author calls *the retort.* Below the grates, spaces were provided to form ashpits with doors for drawing the ashes. The inner retort chamber was also arched, the sides being parallel to those of the outer chamber, with a space between the crown of the arch and the top of the outer chamber of about 9 inches. The bottom was depressed in the centre to form a gutter, and sloped rather steeply towards the back for the purpose of allowing the products of distillation to trickle down towards an outlet in the rear wall. A tapered copper drain pipe was securely built into this opening, and was led through the outer wall of brickwork inclining downwards at the same angle as the floor. The outer small extremity was inserted in the side of a cast-iron vessel embedded to one-half its depth in the ground. A vertical branch pipe 3 feet in height and 2 inches in diameter was brazed to this drain pipe at the point where it emerged from the oven wall. The heavy tarry substances flowed down and were collected in the iron receptacle, while the volatile gaseous products escaped by the vertical branch pipe into the air. The method of working was as follows :—After bringing up a sufficient supply of coal well cleaned and graded to double the size of a man's fist, a workman entered the retort through the door, while another handed him the coal upon a peel ; this he built up carefully inside like a wall, taking great care not to injure the walls of the retort. As he filled up the chamber he retired towards the door until there was just space enough left for him to crawl out, and he then continued the charging from outside until every corner was completely filled. Both doors were then closed and luted up with the same material as that used in the construction of the retort. The capacity of the retort or oven was ordinarily about 2000 lbs. of raw coal, for the "roasting of which about 900 lbs. of the screenings from the same coal was used. As soon as the coal was sufficiently roasted, the pipe provided for the escape of volatile matter ceased to emit smoke, and the smell of sulphur observed throughout the operation became no longer perceptible." "Coal thus roasted," continues the author, "does not emit the least odour in burning, and possesses the further advantage of lasting twice as long as charcoal, as a substitute for which it can be used without the least inconvenience. Further, the oils and tarry substances which are given off in the process possess a value which almost covers the cost. These may be utilized in the following way: They are collected as already mentioned in a receiving vessel, the contents of which are poured into a large tub, and stirred for a long time with wooden stirrers. This forces the oil to rise to the top,



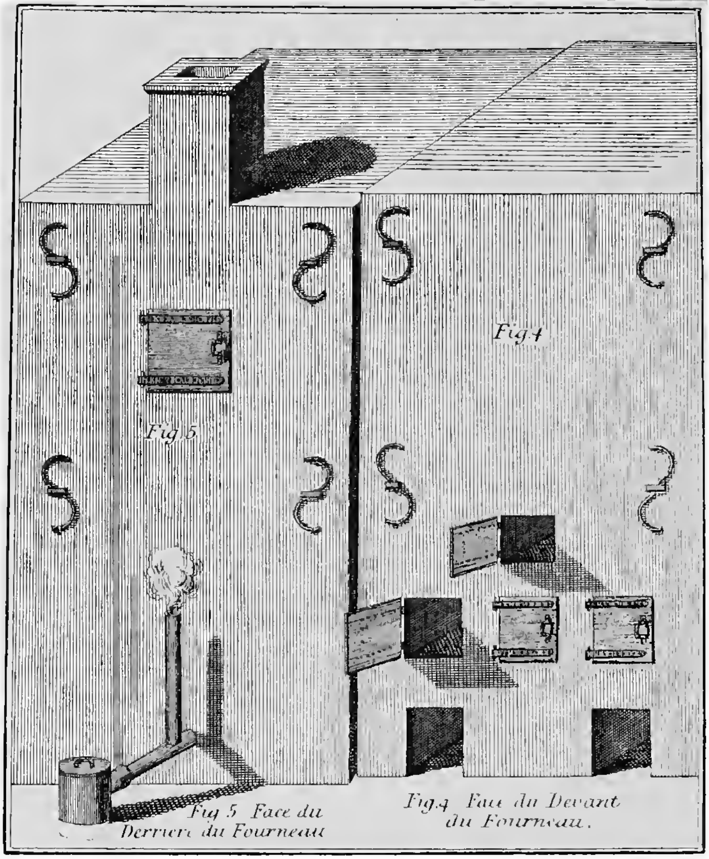


Fig 5 Face du Derriere du Fourneau

Fig.4 Face du Devant du Fourneau.

where it is skimmed off with iron spoons. The bituminous matter settles at the bottom of the tub, and is sometimes pure enough for commercial use without further treatment. It is, however, more often mixed with water, which can be evaporated by heating in a boiler. By this action a woolly substance is formed, which is thrown away ; the pure residue is of a fatty nature and very liquid, and is in no respect inferior to the best lubricating mediums for the wheels of vehicles. As regards the oil, it differs from petroleum only in that, while the latter is very inflammable and flares up all at once, the oil from coal is much less so. It is suitable for use for lamps in country places, and is the only illuminant employed in the mines at Sultzbach, but it gives off a great deal of smoke and a strong smell of naphtha."

Dr. Percy remarks upon this account that "the manufacture of oil for lamps and for the purpose of lubrication, by the distillation, at a low temperature, of cannel coal and other bituminous matters, is carried on largely in this country, and is reported to have formerly yielded a princely income to the firm of Young & Company. The oil thus produced contains paraffin, and is accordingly designated 'paraffin oil' by Mr. Young, who obtained a patent for his invention in 1850. Although the oils used at Sultzbach probably differed somewhat from paraffin oil, yet it is not a little singular that the products obtained so long ago from the distillation of coal should have been employed as agents of illumination and lubrication, just as products also derived from the distillation of coal are now applied to the same purpose.

"The history of the process of coking at the ironworks at Sultzbach is interesting in another point of view, as showing how completely a great practical discovery may obtrude itself, as it were, upon the attention of men, and yet be unperceived. The chamber in which the coal was distilled was essentially a gas retort, and the gas, which issued in a continuous current from the vertical pipe at the back, must often have taken fire and produced a luminous flame; but the idea of applying that gas to the purpose of lighting seems never to have occurred to those who observed it. Large gas works were daily in active operation at Sultzbach, and yet the merit of the invention of lighting by coal-gas was reserved for Mr. Murdoch in 1792, or more than twenty years afterwards."[1]

Some further experiments on the distillation of coal were published in 1781 by Dr. Watson (afterwards Bishop of Llandaff). He "took 96 ounces of Newcastle Coal, and putting them into an earthen retort, distilled them with a fire gradually augmented till nothing more could be obtained from them. During the distillation, there was frequent occasion to give vent to an elastic vapour, which would otherways have burnt the vessels employed in the operation. The weight of the liquid found in the receiver, and of the residuum remaining in the retort, after the distillation was finished, were accurately taken, and was expressed in the following table:

Weight of Newcastle Pit Coal distilled			96 oz.
Weights of the Products	Liquid	12 oz.	
	Residuum	56 ,,	
	Loss of Weight	28 ,,	
			96 oz."[2]

Dr. Watson made similar experiments with different varieties of wood, his object being, apparently, to ascertain the quantity of liquid, or tar, to be obtained from various substances; with regard to which he says that "the quality of the liquid separable from wood by distillation is wholly the same with that of the liquid separable from pit coal by the same means."[3]

Of that which he describes simply as "loss of weight," and to which he attached no other significance, Dr. Watson says: "The matter which is lost during the distillation of both wood and Pit-coal has been called *air*, and it certainly has one, at least, of the most distinguishing properties of *air—permanent elasticity*, for bladders may be inflated with it as with common air. It does not begin to be separated from either wood or coal till the lighter of the two oils begins to appear; it then rushes out with great violence, and unless a proper vent be given to it, the strongest vessels will be burst by it."[4]

Again: "In distilling heart of oak, during the course of chemical lectures which I read in the University of Cambridge in the year 1767, I remarked to the audience that the air which issued with great violence from the oak was inflammable, not only at its first exit from the distilling vessel, but after it had been made to pass through two high bended glass tubes, and three large vessels of water. I at first supposed the inflammability to proceed from some oily particles which had accompanied the air, and which I thought would soon be condensed by the cold, though they had not been condensed in passing through the water; but upon repeating the experiment, and collecting the air in bladders, I found that it retained its inflammability a long time, and burned like the air separable from some metals by solution in acids.

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[1] *Metallurgy*, by John Percy, M.D., &c., pp. 491–2. London, 1875.

[2] *Chemical Essays*, by R. Watson, D.D., F.R.S., vol. ii. p. 317. Cambridge, 1781.

[3] *Ibid*. p. 328.

[4] *Ibid*. p. 328.

"From the researches which have lately been made into this subject, it is now believed, that this kind of air may be separated from all vegetable, animal, and inflammable mineral substances by distillation; and the common burning of wood, coal, paper, pitch, oil, and other combustible bodies, is attributed to this air, which being separated from the body by the heat, and inflamed by the contact of the fire, continues to burn as long as the body continues to afford a proper supply of it. *Inflammable air,* considered in this view, bears a great resemblance to what the chemists have hitherto understood by their phlogiston or food of fire." [1]

These quotations reflect the prevailing ideas on the subject at the time, only a few years prior to Murdoch's demonstration at Redruth. The period was, however, one of great activity in chemical research, and was made notable by a series of important discoveries. Prominent amongst these was that of carbonic acid gas, by Black, in 1754, as the result of an investigation which has been described as "perhaps the most remarkable in the whole history of chemistry"; [2] and of oxygen by Dr. Priestley and, almost simultaneously, by Scheele, in 1774. In the same year also of Watson's publication—namely, 1781—Cavendish commenced his experiments on the nature of hydrogen, which resulted in the discovery that water is the sole product of its combustion. These, coupled with the labours of Lavoisier (who was the first to make what is called "water" gas) and others, were all-important contributions to the study of the composition of aeriform substances, and may therefore be said to have fitly ushered in the era of gas manufacture and distribution. Not, however, that there existed any real connection between the two; or, that the introduction of gas lighting is much indebted to laboratory investigation. This was in reality the work of an eminently practical mind, and constituted a "utilization of the Great Sources of Power in Nature for the use and convenience of man." As such it may indeed have merited the countenance and the aid of science; and one eminent chemist did lend it a helping hand. But since the days of Dr. Henry the favours bestowed by science upon gas manufacture have not been great, and its influence has on the whole been the reverse of beneficial to the progress of the industry.

At this period, also, the distillation of coal for the production of tar, which was commenced, certainly as far back as 1674,[1] seems to have been carried on somewhat extensively, and in this same year (1781) the Earl of Dundonald obtained a patent, which he applied at Culross, for " the extracting of tar, pitch, essential oils, volatile alkalies, mineral acids, and salts, and the making of cinders from pit coal." The method employed consisted in allowing the external air to have a passage or passages through the vessels or buildings in which the coal from which any of the above substances are to be distilled is put. " . . . by which means the said coals, after being kindled, are enabled, by their own heat and without the assistance of any other fire, to throw off in distillation or vapour the tar, oil, alkalies, acids, and salts they contain." The patentee goes on to state that persons who without his permission shall extract tar, &c., from pit coal in vessels or buildings not externally fired—*i.e.*, in which the coal is ignited without flaming by a regulated admission of the external air, so as by its own heat to throw off the tar, &c., which it contains—are " deemed to encroach upon my patent, as the only method used or known until my new discovery, was a distillation of coal in close vessels, where the admission of the external air was prevented, and where other fuel or coals were required besides the coals contained in the close vessel to produce the heat necessary to pervade the same, and to cause the coals contained therein to throw off the tar, oils, &c., that they contained." No drawings accompany the specification, the shape or size of the buildings or kilns to be employed being immaterial ; " the art depending upon the management of the air admitted into the kilns."

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[1] *Chemical Essays*, by R. Watson, D.D., F.R.S., vol. ii. pp. 329–30. Cambridge, 1781.

[2] *A Dictionary of Chemistry*, by Henry Watts, B.A., F.C.S., vol. ii. p. 776. London, 1866.

This departure from the proper method of distillation, which, as will shortly be seen, was also practised by Murdoch, though for a different purpose, is of less interest than the fact that the current of gas escaping from the kilns employed was frequently fired, it having been said also that Culross Abbey was lighted up by means of it. This, however, is incorrect. What was actually done with the gas, of which there must have been a considerable quantity, though of indifferent quality, was told by Mr. John Hart, in the discussion which followed the reading of a paper on " Coal Gas " by Dr. Thomas Thomson, before the Glasgow Philosophical Society on the 1st November, 1843. This was published in the *Transactions* of the Society for that year (pp. 173–5). " Having heard," says Mr. Hart, " that Lord Dundonald used gas from coal as a light long before Mr. Murdock's discovery, and being in Culross Abbey while it was unroofed and in a state of ruin, I naturally began to examine the walls to see if I could discover any trace of the pipes, when Sir Robert Preston's gardener informed me, that he believed no pipes were used, as some of the old people of Culross who saw it, told him that the gas was carried in a vessel from the tar works and burnt in the Abbey.

" I afterwards discovered that an intelligent old man, a blacksmith in our neighbourhood, had been long in the employment of his Lordship, and that he had been assistant in many of his experiments about that period ; from him I received the following account :

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[1] In that year the first patent for the process was granted to Martin Eele, Thomas Hancock, and William Portlock.

"His Lordship having been in company with some scientific friends, on the following morning he mentioned to his blacksmith that, on the previous night, he had been shown a work which gave an account of a process for distilling pit coal, and from which a substance like tar might be obtained in considerable quantities. This he wished to try, as he thought it might be made to serve the purposes of common tar ; and he then told him to come along with him to the garden, where he pointed out a spot, and gave him instructions to set about the erection of an oven or kiln to try it ; the experiment succeeding, nothing more was done until it was secured by a patent. Soon after, nine cylindrical ovens of brick were built in a row, along a bank of earth. These were about 3 feet in width and about 7 feet deep, being hemispherical at top and bottom, each having a movable cover at the top for charging, and a well-fitted door at bottom to regulate the combustion. A 7-inch cast-iron pipe near the top conveyed the products to the condenser on the top of the bank. The condenser was a flat box of lead, having divisions partly crossing it to detain the vapours of the tar, and very much resembled the coolers used by brewers, from having a rim to retain cold water on its upper surface, with which it was plentifully supplied. The tar was conducted by a pipe into similar cylinders of brickwork on the opposite side of the bank ; each of these had a small opening in the top for the escape of the incondensable part of the products. To these openings the workmen were in the habit of attaching a cast-iron pipe by means of a lump of soft clay, and lighting the gas at the other end to give them light during the darkness. His Lordship, also, was in the habit of burning the gas in the Abbey as a curiosity ; and for this purpose he had a vessel constructed resembling a large tea-urn ; this he frequently caused to be filled and carried up to the Abbey to light the hall with, especially when he had any company with him. On one occasion, after a fresh charge, the workman having applied his light too soon, an explosion took place, which nearly killed some of the men, and tore off the top of the condenser, and one of the workmen's wives passing near it at the time was blown off the bank," but escaped "without receiving any other injury than the fright." This is the first recorded instance of the accidental explosion of coal gas. "Such," continues Mr. Hart, "was the state of knowledge on this subject in Scotland ten or twelve years prior to Mr. Murdock's discoveries. As Lord Dundonald's object was the manufacture of tar, his researches would probably be confined to the quantity of tar, and not to the quality of the gas ; and as his gas from the tar kilns must have been very inferior, being from common coal and also partly mixed with the air after combustion in the kilns, the light must have been inferior to candles. But even although he had observed the high illuminating power of gas from cannel coal, the high price of cast-iron pipes, and the little use they were put to, especially in Scotland, at that period must have rendered such an idea, if it had ever occurred to him, . . . as a thing perfectly impracticable."

This process of Lord Dundonald's is described, substantially as above, but in greater detail as to the products derived from it, in the 1808 edition of Nicholson's *Dictionary of Chemistry* under the heading of "Coal." The description concludes by stating that "it has been proposed also to collect the carburetted hydrogen gas evolved from burning coal, and apply it to the purpose of filling balloons, and *affording light*." The italics are ours.

Although not in exact chronological order, mention may here be made of the appearance upon the scene of Mr. Diller, a Dutch chemist, with his Philosophical Fireworks. Matthews gives the date of this as 1784; but it was probably a little later. In 1787, Diller's invention was reported upon to the French Academy of Science by a committee consisting of M.M. Leroy, Brisson, Lavoisier, Monge, Berthollet, and Fourcroy, some of the most eminent men of science of the period. Their report, dated 4th July of that year, appears in the 31st volume of the *Journal de Physique*, pp. 188–195. It was directed mainly to the question of safety, and does not disclose the nature of the inflammable gas employed by Diller, only stating that iron was not used in its production. It was probably hydrogen produced by means of zinc or tin, and carburetted or coloured as desired. It could scarcely have been coal gas, from the description given of the apparatus in which it was generated; "des bouteilles ordinaire, un grand nombre de vessies garnies de tubes & de robinets lui suffisent." The report contains a lengthy description of the apparatus and mechanism employed, and the effects which these were capable of producing. The gas was exhibited in three different colours, namely, white, blue, and green; and the burners were of various sizes and shapes, and arranged so as to represent suns, stars, triangles, and Maltese crosses, and also animals, plants, trees, flowers, fruits, &c. This remarkable exhibition received the eulogium of the Committee, who pronounced it to be perfectly safe, and that Diller merited "des éloges de l'Académie."

Diller opened an exhibition at the Lyceum Theatre in London in 1788. He died in the early part of 1789; but for some time afterwards his exhibition was continued in different parts of this country. The following advertisement appeared in the *Birmingham Gazette* of the 25th May, 1789, and is given in Mr. Langford's *Century of Birmingham Life*, vol. i. p. 399:

"At the New Street Theatre, on Friday next, the 29th May inst., will be displayed the grand exhibition of the newly-invented Philosophical Fireworks (produced from Inflammable Air), being the invention of the late ingenious Mr. Diller, and performed by Mr. Pitt and Mr. Adams—pupils of the late Mr. Diller—who experienced so much public patronage during its exhibition at the Lyceum Theatre, London, which comprise the following Pieces: A fixed Flower.—A Sun turning round, varying in Figure.—A Star varying.—A Triangle.—A Dragon pursuing a Serpent.—A Star of Knighthood.—A Flame proper for Lighthouses, to the Splendour and Brilliancy of which the Rays of 100 Patent Lamps, collected in the same focus, would be much inferior.—A Central Piece, that undergoes 120 Changes of figure, and produces several thousand Flames.—The Prince of Wales' Arms and Feathers, and an Aerostatic Branch, &c."

In the *Birmingham Gazette* of the 1st June following, it is stated of this exhibition that " the beauty and vividness of the various colours of fire could not be exceeded. The variety of forms which the works assumed and represented astonished every beholder, and raised the highest ideas of the mechanical and philosophical talents of that man who invented the complex machinery which produces such delightful effects."

Interesting and ingenious, however, as this exhibition evidently was, it served no useful purpose. It was but a nine days' wonder. It left the field open for Murdoch; although priority has recently been claimed for Jean Pierre Minckelers, who, born at Maestricht in the province of Limburg, Holland, in 1748, became in 1772 Professor of Natural Philosophy at the University of Louvain, and was afterwards Professor of Chemistry and Physics at the Central School established by the Republican Government of France in his native town of Maestricht. Minckelers in 1784, while still at Louvain, published a *Mémoire sur l'air inflammable tiré de differentes substances.* This is an account of experiments made by himself in conjunction with two of his colleagues at the University, at the instance of the Duc d'Arenberg, who was one of its patrons. The Duc had become interested in the invention of balloons in the previous year by Mongolfier; and these experiments were undertaken in the hope of discovering some cheap and ready means of producing large quantities of permanent gas, sufficiently light for aerostatic purposes. With this object the experiment covered a great variety of substances, but particular attention was directed to those which are easily procurable in quantity, and at a small cost. Such a substance, he tells us, is coal, of which a small quantity was powdered and distilled in a gun barrel over a forge fire. The experiment was completely successful, " inflammable air " being obtained in abundance. Four ounces of coal yielded one cubic foot, which, on weighing, was found to be four times lighter than atmospheric air. The first experiments were made with coal in general use in Louvain, but this was found to swell whilst being distilled, causing injury to the retort. A common coal, used for brick-making, was therefore tried, and also another variety, more " close-burning "—both probably non-caking—and these yielded, without any repetition of the previous inconvenience, as much " inflammable air " as the former, but of a lighter specific gravity; its weight as compared with that of atmospheric air, being stated as 15 : 64. Such extremely light gas as seems to have been produced in these experiments could not have had much illuminating power; so that Minckelers may be said to have unconsciously anticipated the present-day requirements for a low-grade gas. He tried to make his gas still lighter by passing it through lime water, but did not find this to result in any advantage. He also tried, upon the lines of some experiments that had previously been made by Priestley, the effect of distilling at a lower temperature—namely, that of an ordinary wood fire instead of that of the forge fire previously employed. This, however, resulted in a smaller yield of gas, the weight of which compared with that of atmospheric air as 10 : 31. He likewise found, by collecting them separately, that the first portions of "air" yielded by distillation are heavier than those that follow; and concluded from his experiments generally, that to obtain the lightest "air" from coal, and at the same time the greatest quantity, a high heat must be employed. These researches place Minckelers in advance of previous experimenters in this direction. He was also the first to use coal gas for inflating balloons. He tells us in the *Mémoire*, that his first experiment was made with a small balloon made of gold-beaters' skin, which his Highness (the Duc D'Arenberg) sent up from the grounds of his Château "on the 21st November last," and this, having broken the string which held it back, went out of sight. Other balloons were sent up on the following 24th February at Louvain. The capacity of one was less than 1 cubic foot; and that of the other nearly 5 cubic feet. Another which was sent up at Antwerp on the 23rd February by Father Walschot, a Dominican, was 3 ft. 2 in. high, and had a diameter of 27 inches. There is nothing, however, in the *Mémoire* to show that Minckelers attached any importance or significance to the lighting power of the gas which he distilled from coal; although it is stated by M. Bolsius that in 1785 he lighted his lecture-room with it, and did so repeatedly in that and the following years. This is quite conceivable. To exhibit the gas to his pupils would be a very natural thing for Minckelers to do. But for about thirty years afterwards (namely, until 1816) he continued in the active practice of his profession without—so far as is known—anything more being heard from him or of him in connection with the application of this gas for lighting purposes. It is therefore correct to say that he carried the matter but little if anything further than where it had been left by previous experimenters, or by Clayton about a hundred years before. Clayton tells us that he frequently lighted up his gas for the amusement of his friends; and Minckelers appears to have done much the same thing. Neither is, however, entitled on that account to be regarded as the inventor of gas lighting. Who, then, was its inventor? Surely he who was the first to demonstrate its utility; the first to show how it could be applied to the use and convenience of man. Such was not Minckelers, nor any of his fellow-experimenters; such, however, was Murdoch.

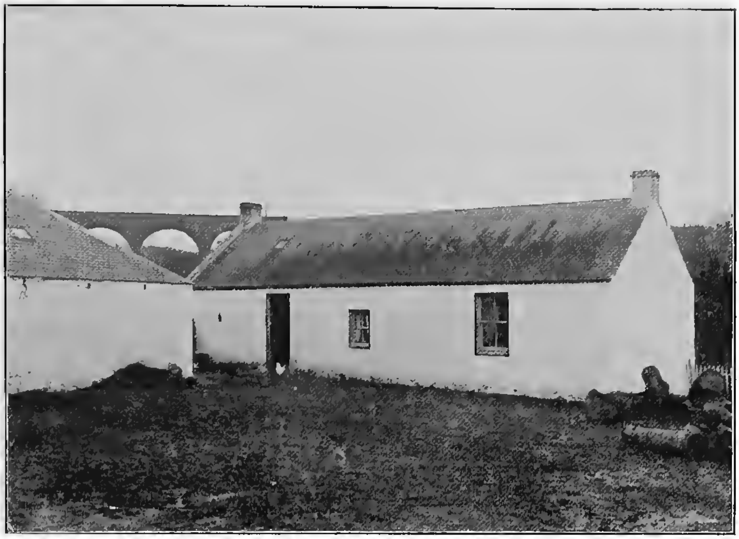
CHAPTER II.

MURDOCH AND LEBON.

WILLIAM MURDOCH, or MURDOCK, according to the English pronunciation, and as his name was spelt by his contemporaries, was born on the 21st August, 1754, at Bello Mill, in the village of Lugar and parish of Auchinleck, Ayrshire, the land o' Burns. Bello Mill is picturesquely situated on Bello Water, where this joins the little River Lugar. It is about two miles from Old Cumnock on the Glasgow and South-Western Railway main line. It may also be reached by a branch line of the same railway from Auchinleck, which passes through Lugar. Above the mill stands the cottage in which Murdoch was born, and which has since been enlarged.

BELLO MILL.

The Murdochs, of whom there were many in the neighbourhood, are supposed to have come over originally from Flanders, and some of them were



BELLO MILL COTTAGE, THE BIRTHPLACE OF WILLIAM MURDOCH.

INTERIOR OF MURDOCH'S CAVE.

ecclesiastical builders or architects of repute. It was a Murdoch who built Glasgow Cathedral; and another, a Frenchman, who took the name of Murdo, died whilst building Melrose Abbey. One John Murdoch was Robert Burns' first teacher at Alloway Miln, near Ayr, and was for some years a friend of the Burns family. A story is told in connection with him which has often been quoted as showing the extreme sensibility of the poet's family. He came on one occasion to spend the night with the latter previous to leaving the neighbourhood, and brought with him as one of his parting gifts, a copy of a tragedy which, to pass away the time, he commenced to read aloud. This so worked upon the feelings of his audience, that presently all were in tears, and he had to desist; the future poet—then but a stripling—declaring that if the book were left in the house he would burn it. This John Murdoch was the author of some works that have long been forgotten. He removed to Ayr in 1772, as English teacher at the Borough School, but fell into sad disgrace a few years later for speaking in terms more forcible than polite of the powers that be, in the person of one Dr. William Dalrymple. " He might as well have spoken blasphemy," says Gilbert Burns, the brother of the poet. He removed to London, where he gave lessons in languages, and is said to have numbered Talleyrand amongst his pupils, during the brief sojourn in this country, as an *emigré*, of that celebrated diplomatist.

William Murdoch's father was also surnamed John. He tenanted, in addition to the mill, a farm belonging to the Bosworth family of Auchinleck, a member of which was the famous biographer of Dr. Johnson. He was, besides being miller and farmer, a skilful millwright. He invented toothed bevelled mill-gearing, the first example of which was, until a few years ago, to be seen on the lawn in front of William Murdoch's house (now demolished) at Handsworth, near Birmingham.

It is said that " Murdoch, when a boy, herded his father's cows along the banks of the Bello; and as there were then no hedges, it was necessary to have some one to watch the cattle grazing. The spot is still pointed out where the boy, in the intervals of his herding, hewed a square compartment out of the rock at the waterside, and there burnt the splint coal found on the top of the Black Band ironstone. . . . This little cavern was provided with a fireplace and vent, all complete. It is possible that he may have there derived from his experiments the first idea of gas as an illuminant." [1] My barelegged guide to this " little cavern " in the autumn of 1901 was a reminder of what Murdoch probably was at the period when he is said to have excavated it. It is situated at the foot of the cliff behind the cottage, and is really of somewhat large dimensions; for it measures superficially 7 or 8 feet each way. That this cave was the sole work of the boy Murdoch may be doubted. Local tradition, indeed, ascribes to it a natural formation, enlarged and improved by Murdoch, who constructed within it a rude fireplace, the vent or flue of which was carried through the garden above and connected to

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[1] *Men of Invention and Industry*, by Samuel Smiles, LL.D., pp. 125–6. London, 1884.

EXTERIOR OF MURDOCH'S CAVE.

BIRD'S-EYE VIEW OF LUGAR, AS SEEN FROM THE IRONWORKS ABOVE.

the kitchen chimney of the cottage. In this he, and possibly others also, burnt the splint coal, whether for mere pastime or for any serious purpose is of no great moment. The cave is sufficiently interesting as evidence of Murdoch's ingenuity and resource at that early age.

Coal was not raised in the neighbourhood in any quantity until a later period, and in Murdoch's time Lugar must have been a charming little village. Now, however, extensive ironworks and collieries frown down upon it from the heights above, and long rows of miners' cottages give it a prosaic appearance. The scenery, however, of the immediate neighbourhood remains characteristic of the "Land of the mountain and the flood!"

Murdoch inherited from his father a taste for mechanics, and derived from him much technical knowledge. Between them, they contrived a wooden horse, on which he used to ride to the neighbouring village of Cumnock, and which was the wonder of the district. This was a forerunner of the modern bicycle. In after years, as will be seen, he followed up his work in this direction, and, but for the intervention of those with whom he was then associated, the locomotive might have been numbered amongst the many inventions of his practical mind. Murdoch, however, was not a machinist only, for he is credited with having built a stone bridge over the River Nith, near Dumfries. Whatever part in this work may be rightly assigned to him, having regard to his youthfulness at the time, it is evidence of his training having been of an all-round character. Far different this to the groove into which so many of our workers are forced by the exigencies of modern industry. Division and sub-

CRIBB'S GLEN, ABOUT 400 YARDS FROM BELLO MILL.

division of labour have become a necessity; yet how many Murdochs may there be amongst us, although lost to the world as such, because their ideas have been narrowed down to the bench at which they perform their daily monotonous task!

Thus equipped, William Murdoch, in his twenty-third year, left his home to seek his fortune amongst strangers. This was in 1777, and he proceeded at once to the Soho Works, near Birmingham, where the celebrated James Watt had shortly before entered into that partnership with Matthew Boulton which was destined to become world-famous. Watt's previous partner in his steam-engine patent was Dr. Roebuck, of Borrowstones, the founder of the Carron Ironworks, where had been made the bevelled mill-gearing invented by the elder Murdoch. It was at Kinneil, near Linlithgow, where Dr. Roebuck lived, that Watt erected his first trial steam-engine, and this was probably known to the Murdochs. Naturally, therefore, the lad Murdoch sought out Watt, whose fame as an inventor was abroad in the neighbourhood. On arriving at Soho, he was seen by the senior partner, Matthew Boulton, who was attracted by the sound made by Murdoch's hat which, in his nervousness, he dropped upon the floor during the interview. This he explained, in answer to Boulton's inquiry, was made of "timmer," and had been turned to the necessary oval shape "in a bit laithey" of his own contriving. Here was an indication of resourcefulness not to be disregarded by such a shrewd judge of character as was Boulton, and as the result Murdoch was engaged by the firm at the not extravagant wage of 15s. per week, which was to be increased to 17s. per week when employed in the country, and to 18s. per week when in London. Thus began a connection which was to last throughout the whole of Murdoch's working life.

Although the engine erected by Watt at Kinneil was not a success, and the inventor had been compelled to turn to the pursuit of general engineering and surveying for a livelihood, he continued to believe in its practicability, and impressed Boulton, whose acquaintance he first made in 1768, with that belief. On Dr. Roebuck's affairs becoming involved a few years later, Boulton took over his share of Watt's patents (two-thirds of the profits, he paying all expenses) for a debt of £1200 owing to him by Dr. Roebuck, who, in addition, was paid £1000 to assist in procuring an extension of the term of the patent. The Act of Parliament, securing this for a further period of twenty-five years, was obtained in 1775, and the Kinneil engine being removed to Soho, it was soon put into working order, with the mechanical appliances there available; the firm then announcing their preparedness to supply engines for general use. These were very shortly in request for pumping at the mines in Cornwall, owing to their great economy of fuel as compared with the Newcomen atmospheric engine which had been previously employed. Messrs. Boulton & Watt asked for royalty one-third of the saving so effected for a term of years. The first engine was erected by the firm at Ting-Tang Mine, Gwennap, and this was quickly followed by two others, one at Wheal Busy, Chacewater, and the other at Owen Vean, near Marazion. This was in 1778, in which year Murdoch was sent to Cornwall to take charge of them. Here he worked hard and incessantly; literally fighting his way through all obstacles; the story being told on the authority of Watt of how on one occasion some of the mining captains "having attempted to bully him, he quietly locked the door of the room in which they were assembled, stripped and, making a dexterous use of those arms with which Nature had supplied him, administered to more than one of their number a lesson of persuasive efficacy, such as they would never forget, and such as he was never called upon to repeat. He was, in truth, of Herculean proportions, and in muscular power nearly unrivalled."[1]

Murdoch became the trusted representative of the firm in Cornwall, and is said to have been the actual inventor of the "Sun and Planet" wheels which were patented by Watt in 1781. These were for the purpose of converting the reciprocating motion of the working beam of Watt's engine into the circular motion of the flywheel, and were resorted to because Watt had been forestalled in his intention to use the simpler arrangement of a crank. There was no originality in the latter, which it was not intended to patent. "The true inventor of the crank rotative motion," said Watt, "was the man who first contrived the common foot lathe; applying it to the engine was like taking a knife to cut cheese which had been made to cut bread." His intention to use it, however, leaked out—in public-house gossip of the workmen, it is said—and it was patented on the 23rd August, 1780 (No. 1263), by James Pickard, a Birmingham button-maker, with whom Matthew Washborough, of Bristol, arranged for applying it in the engine invented by him for securing circular motion.

It has been stated that Murdoch erected in Cornwall the first engine with a separate condenser, which implies that he erected for the firm their first engine in Cornwall, since the separate condenser was the essential feature of Watt's engine. Whether this be so or not, he was certainly in charge very shortly after it was started, and his life at this period and during the next few years is graphically described in a letter written by Boulton to Watt in 1782. "Murdock," he says, "hath been indefatigable ever since he began. He has scarcely been in bed, or taken necessary food. After slaving night and day on Thursday and Friday, a letter came from Wheal Virgin that he must go instantly to set their engine to work, or they would let out the fire. He went and set the engine to work; it worked well for the five or six hours he remained. He left it, and returned to the Consolidated Mines about eleven at night, and was employed about the engines till four this morning, and then went to bed. I found him at ten this morning in Poldice Cistern, seeking for pins and castors that had jumped out, when I insisted on his going home to bed."

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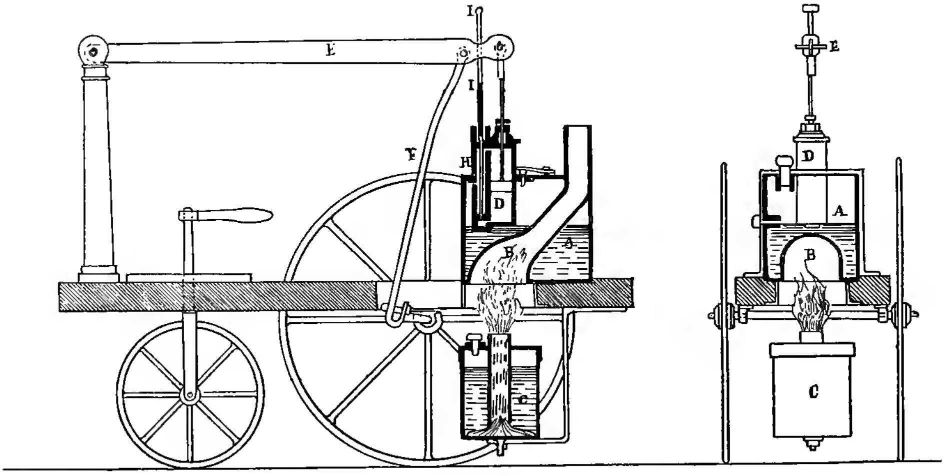
[1] *The Origin and Progress of the Mechanical Inventions of James Watt*, by J. P. Muirhead, M.A., p. 214. London, 1854.

WILLIAM MURDOCH.

From a Bust in the possession of G. Tangye, Esq.

Although so immersed in business, Murdoch found time to devote to his old hobby of locomotion. He constructed a working model of a road carriage, this time to be propelled by steam. This model (see Illustration) was in the Great Exhibition of 1851, and remained in the continuous possession of the Murdoch family until 1883, when it was purchased from Murdoch's great-grandson by Sir Richard and Mr. George Tangye, by whom it has been presented to the Birmingham University. This original locomotive, the first ever run in England, although not the first of its kind,[1] is made upon the principle of the non-condensing engine described in the 4th article of Watt's specification of 1769. It was constructed entirely by Murdoch's own hands. It stands altogether about 14 inches high, is 19 inches long, and the extreme width over the driving wheels is 7 inches. The boiler A is a rectangular vessel, made of brazed copper, $3\frac{3}{8}$ inches high, $4\frac{1}{4}$ inches long, and $3\frac{1}{8}$ inches wide. Through this the flue B passes obliquely, and it is heated by the spirit lamp C. The cylinder D, $\frac{3}{4}$ inch diameter and 2 inches stroke, is fixed on the top of the boiler, and the piston-rod is connected to the end of the vibrating beam E, to which is attached the connecting rod F, for working the crank of the driving wheels. H is a double cylindrical slide-valve worked by the beam E, which strikes the shoulders I I on the valve spindle, and the steam is exhausted through the hollow spindle of the valve passing out near the top. One of the wheels only is fixed upon the crank axle. A steering wheel in front working in a swivel frame allows the engine to run in a small circle.



WORKING MODEL OF A ROAD CARRIAGE, MADE BY WILLIAM MURDOCH.

The following appreciative remarks have been published by the Messrs. Tangye: "An attentive examination of the model well repays one, and reveals many beautifully simple contrivances, showing Murdoch's genius for the adaptation of simple means to secure his desired ends. . . .

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[1] A road locomotive made by Cugnot in 1769–70 is still preserved in the Conservatoire des Arts et Metiers at Paris.

"The steam valve is very ingenious, and it is driven from the beam by a projecting rod, so arranged that the valve is moved at the termination of every up and down stroke by the last portion of movement of the beam upwards or downwards. It is a piston valve, with two pistons ground to work easily, but pressure proof, in the valve cylinder. The space between the pistons is in constant communication with the boiler, and the steam is admitted by two ports—one at the top and one at the bottom of the cylinder, so arranged that when the piston valve is up the steam enters the upper port and drives down the piston, while the exhaust steam from the under side discharges from the cylinder by the lower port through a tube connecting the two pistons of the valve, and out into the air.

"This is probably the earliest slide valve used in a steam-engine, as at the date of its construction Boulton & Watt did not use Murdoch's D slide in their engines, but still adhered to disc valves, with much driving gear.

"Murdoch's invention of the slide valve immensely simplified the steam-engine, by substituting one plain to-and-fro movement for the complex levers and numerous valves of the earlier steam-engines. In this model Murdoch had certainly the idea of the slide valve.

"The safety valve is let into the boiler near the steam cylinder, and it is held down by a little tongue of metal—a very efficient and simple contrivance.

"A lead weight is placed above the steering wheel to balance the machine and to prevent it tipping over when the water is in the boiler, hung behind the driving wheels.

"The wheels are constructed of brass tube brazed together. Every part of the machine is both well designed and well made. It is interesting to observe that at one time the wood under the boiler has been on fire, and it shows still the marks of charring, and is pieced and protected with an iron plate to prevent a similar mishap."

William Buckle, of Soho, Birmingham, read a paper before the Institution of Mechanical Engineers on the 23rd October 1850, "On the Inventions and the Life of William Murdock," in which it is stated that this engine "was seen in 1784 by persons still living, drawing a small model waggon round a room in his (Murdock's) house at Redruth, where he then resided." Mr. Buckle further relates that "at the time that Mr. Murdock was making his experiments with his locomotive engine, he greatly alarmed the clergyman of the Parish of Redruth. One night, after returning from his duties at the mine, he wished to put to the test the power of his engine, and had recourse to the walk leading to the church. This was rather narrow, but kept rolled like a garden walk, and was bounded on each side by high hedges. The night was dark, and he alone sallied out with his engine, lighted the lamp under the boiler, and off started the locomotive with the inventor in full chase after it. Shortly after he heard cries of terror; it was too dark to perceive objects, but he soon found that the cries for assistance proceeded from the worthy pastor, who, going into the town on business, was met in this lonely road by the fiery monster, whom he subsequently declared he took to be the Evil One *in propria persona*."

A more prosaic account of this incident was given by the daughter of this "worthy pastor," Mrs. Rogers, who, "though but a child when her parents told the story," gave, when interviewed, the following with all the freshness of a modern event :

"On a dark evening her parents returning from Redruth to the Vicarage were somewhat startled by a fizzing sound, and saw a little thing on the road moving in a zigzag way. Murdock was with it ; her parents knew him well. They understood that Murdock wished the experiment to be kept secret, and she does not recollect ever hearing of it afterwards, though she frequently saw Murdock, and heard of his engineering occupations." [1]

From this it will be seen that literary embellishment is not a modern art. It seems a pity, however, to spoil so good a story.

Watt had long thought on the subject of locomotives, his attention having been drawn to it some years previously by his friend Dr. Robison, of the Glasgow University ; and he actually described a locomotive in his patent of 1784. He appears, however, to have decided in his own mind against its practicability, and when he heard of Murdoch's experiments offered him no encouragement, but wrote to Boulton, advising that he should be gently counselled to give up the scheme. "As to my own part," he wrote, "I shall form no obstacle to the scheme. My only reasons against it were that I feared it would deprive us of a valuable man ; that it would, if we were to be concerned in it, divert us from more valuable business, and perhaps prove a sinking fund ; and lastly, that I did not like that a scheme which I had revolved in my mind for years and hoped to be able at some favourable time to bring to perfection, if capable of it, should be wrested from me, or that I should be compelled to go into it as a secondary person. But I have now made the latter objection give way. And as to the first, I think it will take place at any rate, so we must make the best of it." Boulton was, however, "recommended in the first place to endeavour to dissuade Murdoch from pursuing the subject further ; but if he could not succeed in that, rather than lose him, he was to let him have an advance to the extent of £100, to enable him to prosecute his experiments ; and if within a year he succeeded in making an engine capable of drawing a postchaise carrying two ordinary persons and the driver, with 200 lbs. of luggage, fuel for four hours and water for two hours, going at the rate of four miles an hour, then a partnership was to be entered into, in which Boulton & Watt were to find the capital, and Murdoch was to conduct the business and take his share of the profits." [2]

On the 8th November, 1784, however, Boulton writes to Watt : "I have also prevailed on him" (Murdoch) "to put off his determined journey to

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[1] *Life of Richard Trevithick*, by Francis Trevithick, vol. i. p. 148. London, 1872.

[2] *Lives of Boulton and Watt*, by Samuel Smiles, p. 337. 1865.

Scotland until North Downs engines are got to work, and have quieted his mind about wheel carriages till then."

The following extract from a hitherto unpublished letter written at Truro nearly two years later—namely, 2nd September, 1786—by Boulton to Watt, shows how, notwithstanding the dissuasion of the partners, it was, by the merest accident after all, that the invention was suppressed.

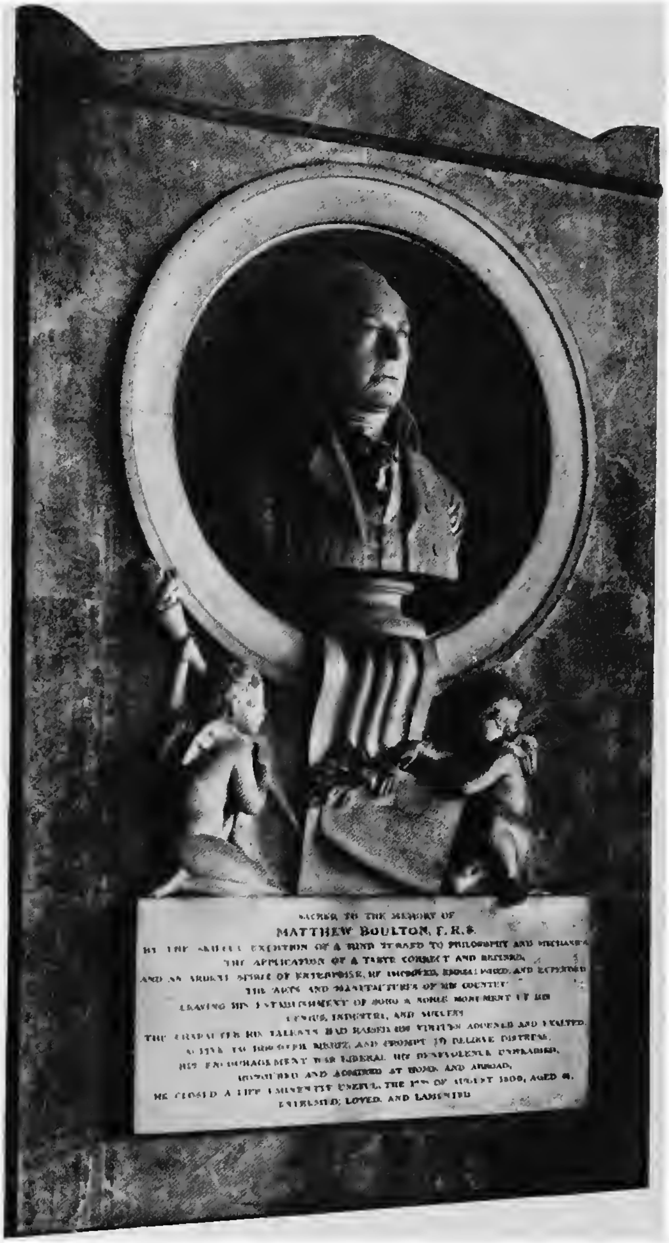
"I arrived at Exeter on Wednesday night, and set out from there on Thursday afternoon to sleep at Oakhampton. About one mile on this side of Exeter I met 3 of the Foxes going to a general Quakers' meeting at Gloucester, and in the same coach was Wm. Murdock. He got out and we had a parley for some time. He said he was going to London to get men, but I soon found he was going there with his Steam Carriage to show it and to take out a patent, he having been told by Mr. Wilkinson what Sadler had said, and he had likewise read in the newspaper Symington's puff, which had rekindled all William's fire and impatience to make Steam Carriages. However, I prevailed upon him readily to return to Cornwall by the next day's diligence, and he accordingly arrived here this day at noon, since which he hath unpacked his carriage and made travel a mile or two in River's great room in a circle, making it carry the fire shovel, poker, and tongs. I think it fortunate that I met him, as I am persuaded I can either cure him of the disorder, or turn the evil to good; at least I can prevent a mischief that would have been the consequence of his journey to London."

Who can measure the consequences of this chance meeting? But for it steam locomotion might have become an accomplished fact long before the days of George Stephenson; but for it, also, the practical genius of Murdoch might have been lost to gas lighting, which, left to the imagination of Winsor, would probably have been indefinitely postponed.

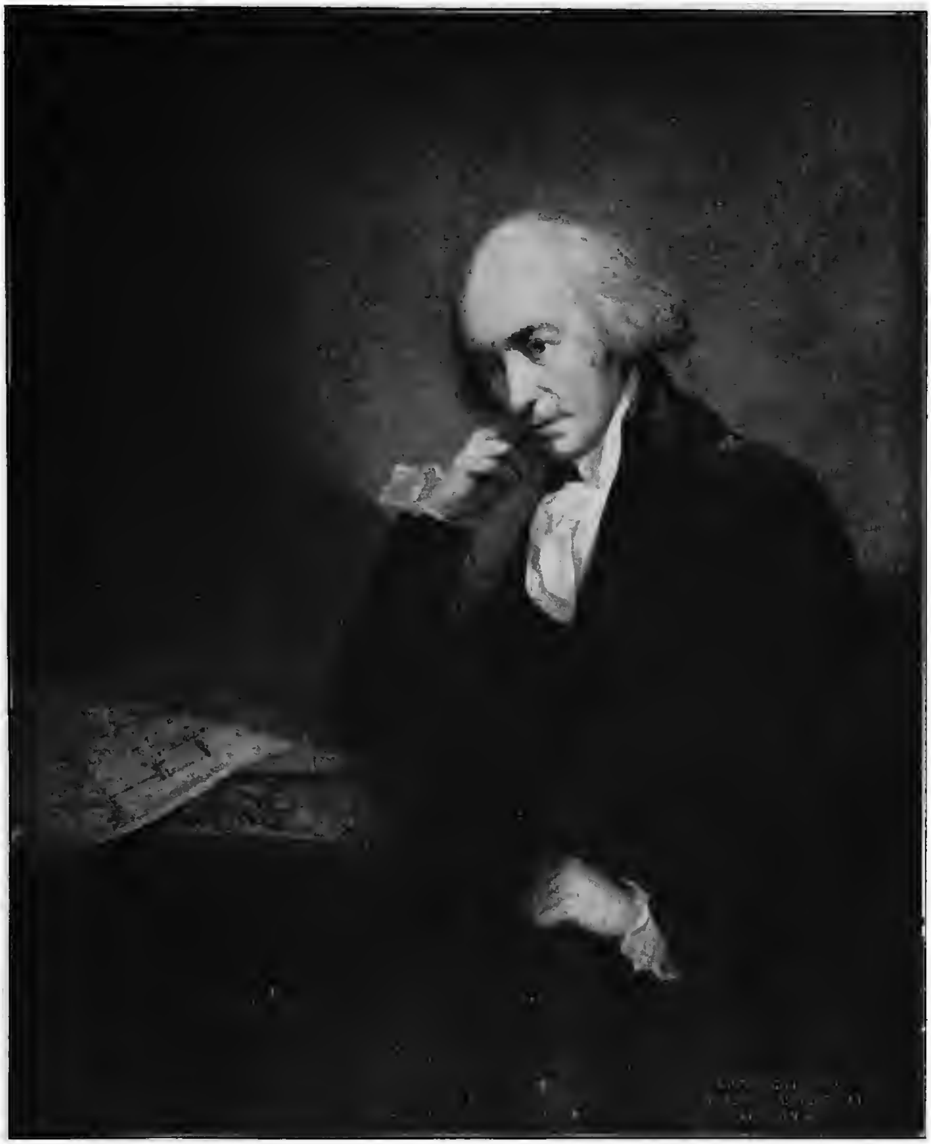
Replying to this letter on the 12th of the same month, Watt says:

"I am extremely sorry that W. Murdock still busies himself with the steam carriages. In one of my specifications I have secured it, as well as words could do. According to my ideas of it, and if to that you add Symington's and Sadler's patents, it can scarcely be patentable, even if free of the general specification in the Act of Parliament; for even granting that what I have done cannot secure it, yet it can act as a prior invention against anybody else; and if it cannot be secured by patent, to what purpose should anybody labour at it? I have still the same opinion concerning it that I had, but to prevent as much as possible more fruitless argument about it, I have one of some size under hand. In the meantime, I wish William could be brought to do as we do, to mind the business in hand, and let such as Symington and Sadler throw away their time and money in hunting shadows."

Later, he is relieved to find "that William applies to his business." Nothing further was ever done in the matter by either Watt or Murdoch, although the latter continued to believe in the practicability of his idea. It has, indeed, been asserted that he constructed for himself a steam carriage



TABLET IN HANDSWORTH CHURCH, BIRMINGHAM.



Emery Walker, Photo.

JAMES WATT.

From the Portrait by G. F. De Breda, in the National Portrait Gallery.

sufficiently large for use in going to and from the mines ; but had he done so he must have anticipated Trevithick in this matter. This has not been claimed for him except as regards the model which he made with his own hands ; and there is no evidence of his having revived the subject after his abortive attempt to secure a patent for his invention. In this connection Watt is seen to be, as he describes himself, " not enterprising," or as he is described by his friend Dr. Robison, " timid, easily frightened by rubs and misgivings, and too apt to despond." This was partly constitutional, but was also largely due to the ill-health from which he suffered during the greater part of his life. At the same time he was a man of warm friendships, and modest in regard to his own achievements. We seem also to see in the incident a weak side of Murdoch's character, inasmuch as he was easily turned from his purpose. He was, however, at that time far from occupying a position of independence. He was receiving a very slender salary—20s. per week according to one account—but probably somewhat more. He had also, in the previous year (1785) taken to himself a wife, who was a daughter of Captain Paynter of Redruth, by whom he had four children, and who died in 1790. At the same time it does seem a little surprising that the firm were able on such terms to retain his services. He had, it is said, more than one offer to leave them and remain in Cornwall ; and when in 1798 his intention to return permanently to Soho became known, the Adventurers in the mines offered him, it is said, £1000 per annum to stay with them. His refusal of such a liberal offer may have been influenced by the great prestige which the firm of Boulton & Watt at that time enjoyed. He very likely foresaw that it would be more to his ultimate advantage to remain with them and share this prestige, than to start on his own account in Cornwall. Moreover, " William " was treated with a degree of confidence that begat loyalty and attachment. " It gives me joy to hear of your good success in London," he writes to Watt at a later date.

The D slide valve referred to by the Messrs. Tangye[1] came into general use, and was so great an improvement as, by itself, to justify their description of the inventor as " second in importance " (as regards the invention of the steam-engine) " to Watt himself." It was patented by Murdoch in 1799, together with several other improvements and inventions. These comprised—(1) a method of boring cylinders by means of an endless screw working into a toothed wheel, instead of spur gear, so as to produce a more smooth and steady motion ; (2) steam cases for cylinders, cast in one piece instead of in segments as had been the previous practice ; (3) a rotary engine. This (see next page) consisted of two wheels A A, with teeth B B working into each other and fixed in a case C fitting close to the sides of the two wheels and the ends of the teeth, these parts being made steam tight by means of packing D. The steam is admitted on the upper side at E, and presses on the teeth of the two wheels, driving them round in the direction of the arrows, and passing out to the condenser at F. One of these engines, of about ½-horse power, was applied at the Soho Foundry, about the year 1802, to drive the machine in Murdoch's private workshop, and continued there, more or less in constant work, for about thirty years.

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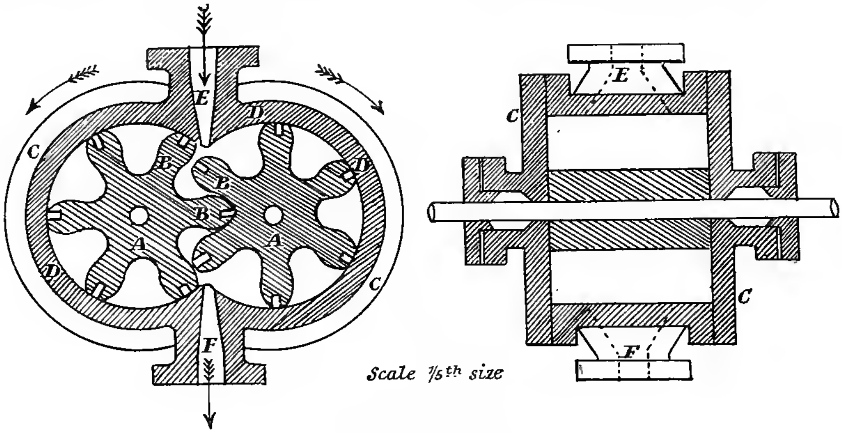
[1] See p. 32.

As to the time when Murdoch first turned his attention to gas lighting, there can be but little doubt. In his paper which was read before the Royal Society on the 25th February 1808, and was therefore probably written during the previous year, he mentions that "nearly sixteen years" previously he had been induced to try the combustible property of the gases produced from coal and other substances. "Nearly sixteen years" takes us back almost to 1791, in which year Murdoch took out a patent (No. 1802) for "treating certain ores to obtain Green Vitriol, pigments, and composition for preserving ships' bottoms, &c.," the method pursued being to burn pyrites (commonly called in Cornwall mundick) with just sufficient air to support combustion, and condense the "fumes or smoke" in a receiver with production of "a fine yellow powder." Whatever may have been the practical value of this process, which was not one of distillation, it is evident that the experiments to which it gave rise, in conjunction with his previous observations, led him to the subject with which his name was to be inseparably associated.

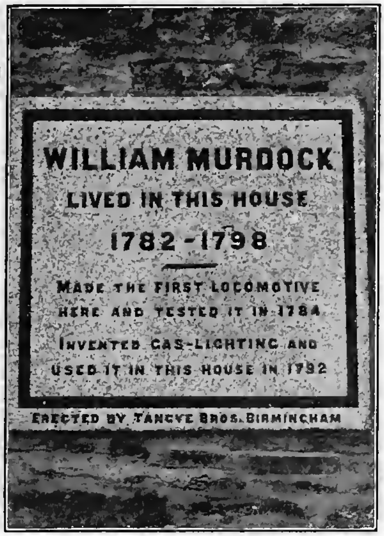


MURDOCH'S ROTARY ENGINE.

All accounts agree that the following year, namely, 1792, Murdoch lighted up his house at Redruth with coal gas. This house still stands in Cross Street, and has in its end wall a suitably inscribed tablet furnished by the Messrs. Tangye. By what experiments this practical demonstration was preceded can only be conjectured; but an interesting light is thrown upon them by a letter from a Mr. M. S. Pearce, dated 23rd April, 1876, and first made public by Dr. Smiles in *Men of Invention and Industry* (pp. 136–7). "Some time since," Mr. Pearce writes, "when in the West of Cornwall, I was anxious to find out whether any one remembered Murdock. I discovered one of the most respectable and intelligent men in Camborne, Mr. William

Symons, who not only distinctly remembered Murdock, but had actually been present on one of the first occasions when gas was used. Murdock, he says, was very fond of children, and not unfrequently took them into his workshop to show them what he was doing. Hence it happened that on one occasion this gentleman, then a boy of seven or eight, was standing outside Murdock's door with some other boys trying to catch sight of some special mystery inside—for Dr. Boaze, the chief doctor of the place, and Murdock, had been busy all the afternoon. Murdock came out, and asked my informant to run down to a shop near by for a thimble. On returning with the thimble, the boy pretended to have lost it, and, whilst searching in every pocket, he managed to slip inside the door of the workshop, and then produced the thimble. He found Dr. Boaze and Murdock with a kettle filled with coal. The gas issuing from it had been burnt in a large metal case, such as was used for blasting purposes. Now, however, they had applied a much smaller tube, and at the end of it fastened the thimble, through the small perforations made in which they burned a continuous jet for some time."

MURDOCH'S HOUSE AT REDRUTH, AS SEEN TO-DAY.

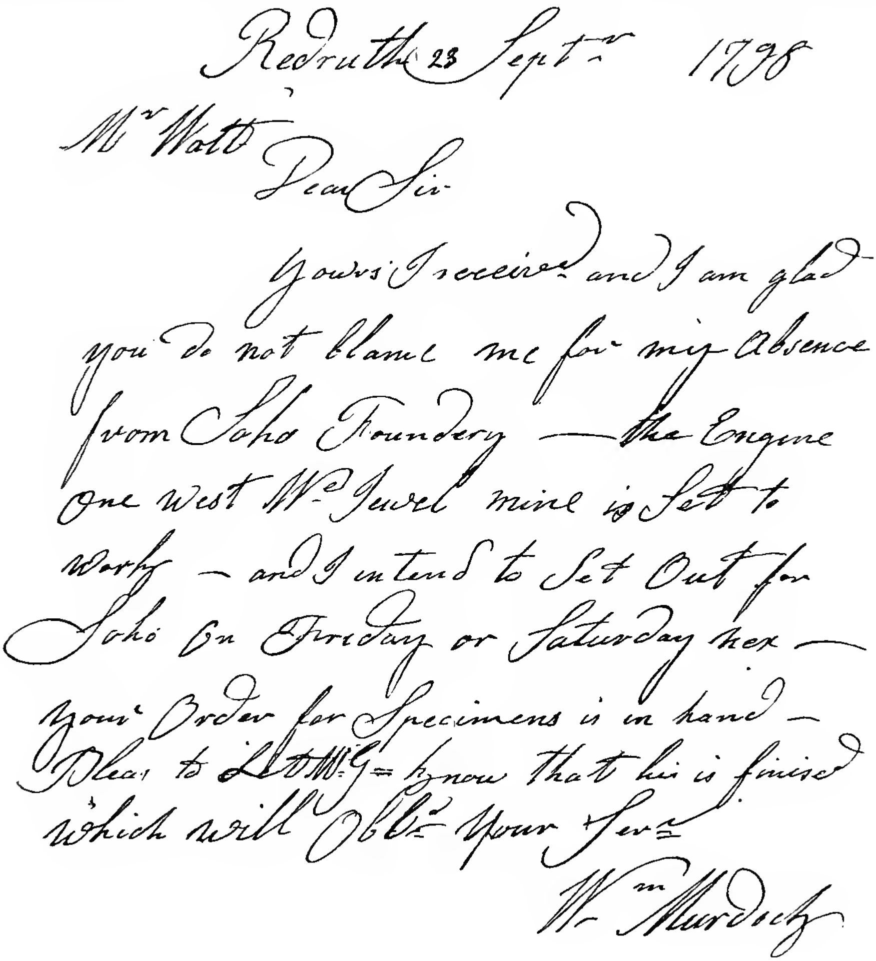

WILLIAM MURDOCK
LIVED IN THIS HOUSE
1782-1798
MADE THE FIRST LOCOMOTIVE
HERE AND TESTED IT IN 1784
INVENTED GAS-LIGHTING AND
USED IT IN THIS HOUSE IN 1792
ERECTED BY TANGYE BROS. BIRMINGHAM

TABLET PLACED BY THE MESSRS. TANGYE IN THE WALL OF MURDOCH'S HOUSE AT REDRUTH.

The development of these experiments into a practical application of the light was told for the first time in a letter addressed to Dr. Wm. Henry, of Manchester, and published by him in Nicholson's *Journal* for 1805 (vol. ii. pp. 73 and 74). The name of the writer is not given, but is evidently that of some one who was then engaged at Soho; probably Henry Creighton, who afterwards wrote the article on "Gas Lights" in the Supplement to the 4th, 5th, and 6th editions of the *Encyclopædia Britannica,* published in 1824. The letter says: " In the year 1792, at which time Mr. Murdock resided at Redruth in Cornwall, as Boulton & Watt's principal Agent and Manager of engines in that county, he commenced a series of experiments upon the quantity and quality of the gases contained in different substances. In the course of these he remarked that the gas obtained by distillation from coal, peat, wood, and other inflammable substances, burnt with great brilliancy upon being set fire to; and it occurred to him, that by confining and conducting it through tubes, it might be employed as an economical substitute for lamps and candles. The distillation was performed in iron retorts, and the gas conducted through tinned iron and copper tubes, to the distance of 70 feet. At this termination, as well as at intermediate points, the gas was set fire to, as it passed through apertures of different diameters and forms, purposely varied with a view to ascertaining which would answer best. In some, the gas issued through a number of small holes, like the head of a watering-can; in others it was thrown out in thin long sheets, and again in others in circular ones, upon the principle of Argand's lamp. Bags of leather and of varnished silk, bladders, and vessels of tinned iron were filled with the gas, which was set fire to and carried about from room to room, with a view of ascertaining how far it could be made to answer the purpose of a movable or transferable light. Trials were likewise made of the different quantities and qualities of gas produced by coals of various descriptions, such as the Swansea, Haverfordwest, Newcastle, Shropshire, Staffordshire, and some kinds of Scotch coals.

" Mr. Murdock's constant occupation prevented his giving further attention to the subject at that time; but he again availed himself of a moment of leisure to repeat his experiments upon coal and peat, at Old Cumnock in Ayrshire, in 1797; and it may be proper to notice that both these, and the former ones, were exhibited to numerous spectators, who, if necessary, can attest them. In 1798, he constructed an apparatus at Soho Foundry, which was applied during many successive nights, to the lighting of the building; when the experiments upon different apertures were repeated and extended upon a large scale. Various methods were also practised of washing and purifying the air, to get rid of the smoke and smell. These experiments were continued, with occasional interruptions, until the epoch of the peace in the spring of 1802, when the illumination of the Soho manufactory afforded an opportunity of making a public display of the new lights; and they were made to constitute a principal feature of that exhibition. I do not know at what time the first trials were made or published in France. The first notice we received of them here was in a letter from a friend at Paris, dated the 8th November, 1801, in which he desires me to inform Mr. Murdock, that a person had lighted up his house and gardens with the gas obtained from wood and coal, and had it in contemplation to light up the city of Paris."

Referring to what may be called the completed experiment of 1792, Mr. Francis Trevithick says, that " those still live who saw the gas-pipes conveying gas from the retort in the little yard to near the ceiling of the room just over the table; a hole for the pipe was made in the window frame."[1] It is clear from these statements that Murdoch did not merely exhibit gas light as others had done—as a curious and interesting phenomenon; but was the first to recognize its economical value, and apply it to practical use. It is said that at this time he also constructed a gas lantern which he used for lighting himself home at night when returning from the mines. This was formed by filling a bladder with gas and fixing a jet to the mouthpiece, which was attached to the bottom of a glass lantern, with the bladder hanging underneath.



Redruth 23 Septr 1798

Mr Watt

Dear Sir

Yours I received and I am glad
you do not blame me for my Absence
from Soho Foundery — the Engine
One West Wl Jewel mine is Set to
work — and I intend to Set Out for
Soho On Friday or Saturday nex —
Your Order for Specimens is in hand —
Pleas to Let Mr G— know that his is finisd
which will Oblige Your Servt

Wm Murdoch

That but little was done with the invention for several years after 1792, was due mainly to the reluctance of Messrs. Boulton & Watt to take it up.

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[1] *Life of Richard Trevithick*, by Francis Trevithick, vol. i. p. 64. London, 1872.

This is apparent from the evidence which was given in 1809 by James Watt, junior, before a Committee of the House of Commons, in opposition to the Bill promoted by the National Heat and Light Company. Before quoting this, however, it is desirable to mention that Murdoch finally left Cornwall and settled at Soho in the year 1798. For some little time previously he had been spending his time between the two places. Thus on the 25th February, 1797, he writes to the firm from Redruth: "My bad state of health since I came to Cornwall has prevented me from returning to you according to your request, which I am sorry for; but my health is now much recovered, and I intend to set out the end of next week with Mr. Wilson." The latter gentleman was at that time the firm's Agent in Cornwall. On the 10th June following, James Watt, junior, writes from Soho to Boulton, then in London: "Mr. R. Fox, of Falmouth, and John Williams, of Scorier, dined at Heathfield yesterday. They are upon a mining adventure in the neighbourhood of Exton Mine, and called here *en passant* to take Murdock with them."

In the letter to Dr. Henry already quoted,[1] it is stated that Murdoch repeated "his experiments upon coal and peat at Old Cumnock in Ayrshire, in 1797;" and this statement is accepted by most writers on the subject, some giving the date as 1798. The writer of this letter was contemporary with the events which he relates; and it is therefore difficult to suppose him to have been mistaken. No mention, however, of the circumstance is made by either Mr. Buckle or Dr. Smiles, or by Murdoch himself in his account to the Royal Society in 1808. It does not necessarily follow from James Watt, junior's letter of the 10th June, 1797, quoted above, that Murdoch was then at Soho, but we certainly find him at Redruth in the following year. This appears from an autograph letter bearing date 23rd September, 1798, which is reproduced on the preceding page.

If, therefore, he was at Old Cumnock at any time during 1797 or 1798, it can only have been in what Creighton calls "a moment of leisure," and not, as has been stated, for the purpose of establishing himself in business there. Inquiries on the spot have failed to elicit any confirmation of this visit.

There is a previous letter from James Watt, junior, an extract from which will be read with interest, as indicating the condition of Murdoch's fortunes during his residence in Cornwall. The letter, which is highly creditable to the writer of it, is dated from Soho, 2nd January, 1796, and is addressed to Messrs. Boulton & Watt, then in London. In it the writer says: "Being upon the subject of remuneration, I cannot help also putting in a few words for poor Murdock, who has lost a considerable part of his salary in Cornwall, and although you have done the same, and that, strictly speaking, it may be said that having put his fortunes into the same vessel with yours you ought to sink or swim together, yet, as he has only one ship to trust to and you have many, I think that something should, in point of justice and gratitude for his uniform attention to your interests, be done for him, and I therefore suggest the propriety of B. & W. giving him £100, and of B. W. & S. and the foundry giving him £25 each.

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[1] P. 42.

" When I propose these donations I ought to add that the profits upon the closure of last year's books are such as will fully warrant our being generous."

The writer of this letter was the eldest son of James Watt by his first wife, who was the partner of his early struggles, and who died in 1773, just as he was emerging from them. This lady is described as having been " a very amiable person, whose gentle counsels and uniform good temper had often sustained her husband's hopes and animated his exertions under the depressing circumstances of indifferent health, narrow means, and variable and often desponding spirits."[1] " I beg you would not make yourself uneasy," she wrote to him during one of his darkest periods, " though things should not succeed to your wish. If it [the new steam-engine] will not do, something else will. Never despair."

On his father's retirement in 1800, young Watt continued the business in partnership with a son of Matthew Boulton. He was of pronounced liberal opinions, and embraced with enthusiasm the tenets of the French Revolution. He and a Mr. Cooper were in 1792 deputed by the " Constitutional Society " of Manchester to proceed to Paris and present an address of congratulation to the Jacobin Club, which was then known as the Société des amis de la Constitution. According to Southey, he was the means of preventing a duel between Danton and Robespierre, to the former of whom he acted as second. He and his friend Cooper were denounced by Burke in the House of Commons on 4th March, 1793, for presenting this address, and carrying the British colours in a procession. He soon, however, became disgusted with the excesses of his friends, and exerted himself to restrain them. " This partial change of sentiment led to a curious result ; for Robespierre, having then insinuated in one of his addresses at the Club of the Jacobins that Cooper and his compatriot were emissaries of Pitt, Mr. J. Watt, with the same fearlessness with which he had previously supported a cause which he imagined to be just, took an instant opportunity of confronting that monster in his own arena — he indignantly sprang on the tribune, from which by main force he ejected the truculent orator, and in a brief but impressive harangue, delivered in French, which he spoke with perfect fluency and an excellent accent, silenced his formidable antagonist, carrying with him the feelings of the rest of the audience, who expressed their sense of his honest British spirit in a loud burst of applause ! On returning home, having learned by sure intelligence from one deep in the secrets of his dangerous foe, that his life was no longer safe for a day, he instantly quitted Paris, without even a passport. He succeeded, though with some difficulty, and occasionally at great hazards, in making his way to the South, and never rested till he arrived in Italy."

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[1] *The Origin and Progress of the Mechanical Inventions of James Watt,* by J. P. Muirhead, M.A., vol. i. p. 144. London, 1854.

"I went over to Paris," said the poet Wordsworth to the author of the work from which the foregoing is quoted, "at the time of the Revolution of 1792 or 1793, and so was pretty hot in it; but I found Mr. J. Watt there before me, and quite as warm in the cause."[1] Young Watt, then, was in good company; and his proposed recognition of Murdoch's services, already referred to (see pp. 44–45), shows that his generous instincts had not deserted him later.

Murdoch's salary on his return to Soho was £300 per annum, plus a commission upon sales. It has been stated that he then received £1000 per annum, but the papers relating to the firm of Boulton & Watt which are now in the possession of the Messrs. Tangye, make it clear that his income from the two sources above named did not in any one year prior to 1816 exceed £700. The highest amount appears to have been reached in 1809–10, the account of which is as follows.

"Statement of Mr. Murdock's Salary and Commission from 30th September, 1809, to 30th September, 1810.

Salary	£300 0 0
Commission at 1 % on £31,757	317 10 0
Additional Commission 1½ % on £4440, amount of lighting apparatus made this year	66 10 0
	£684 0 0"

Murdoch was, however, able to intrust the firm with savings to a substantial amount, according to a note which is in existence, dated 17th January, 1805, authorizing the payment to him of interest at 4 per cent. (not a high rate, especially for those days) on £3000, the amount, apparently, of his investment in the business at that date. Muirhead says that "he always received a liberal income from his employers; and from 1810 to 1830 he was placed in *the footing of a partner*, without having to advance a shilling of capital to the partnership funds, without the risk of incurring any liability, and with a fixed salary of £1000 per annum assigned to him, in lieu of a share of the fluctuating profits."[2] The documents from which we have quoted do not tend to confirm this not quite consistent statement.

We come now to the evidence, already referred to, of James Watt, junior. After stating that he had known Murdoch for thirty years, Watt said that the latter communicated his idea respecting combustion of inflammable gas from coal in 1794 or 1795. He then informed him that, about two years before that period, he had made various experiments in Cornwall, from which he deduced that a very considerable economy would attend the use of gas from coal, in producing light as a substitute for oil and tallow. He did not then show any experiments, for he saw him but a short time, as he was then living

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[1] *The Origin and Progress of the Mechanical Inventions of James Watt*, by J. P. Muirhead, M.A., vol. i. p. 260 *et seq.* London, 1854.

[2] *Ibid.* vol. i. p. 214.

[*Emery Walker, Photo.*

SCIENTIFIC CELEBRITIES IN 1800.

From the Print in the National Portrait Gallery, amongst whom are included Watt, Boulton, and Murdoch.

in Cornwall, and only passing through Birmingham. The first experiment he saw was in 1798. Murdoch then constructed a retort of iron with a tube from it, of perhaps about 30 or 40 feet in length, and to the end of it he applied burners of various dimensions, and gave light during the night time to one of the buildings of the Soho Foundry. Mr. Murdoch at that time proposed, either in 1795 or 1798, that a patent should be taken out for this invention. "I am confident," continued Watt, "he mentioned it in 1798, but am not certain that it was not mentioned also in 1795. I told him I was not quite certain if it were a proper object for a patent, and I was induced to be rather nice upon the subject of patents, from being at that time engaged in carrying on the defence of a patent which my father had obtained for improvements in the steam-engine, and which had then occupied more than four or five years, and been attended with a great expenditure of money. The other reasons were, that it was known to me that the current of gas obtained from the distillation of coal in Lord Dundonald's tar ovens, had been occasionally set fire to, and also that Bishop Watson and others had burnt the gas from coal after condensing it through tubes, or had burnt it as it issued from the retort.

"I advised Mr. Murdock not to prosecute his experiments for the present, until the question respecting the steam-engine had been decided, and until we had an opportunity of considering the subject more maturely. Murdock acquiesced, and nothing was done until 1801.

"At the end of that year my brother went over to Paris; and he wrote me a letter telling me that if we intended to do anything with Mr. Murdock's light, no time should be lost; because he had heard that a Frenchman of the name of Lebon was at the same period endeavouring to apply the gas obtained from the distillation of wood to similar purposes. He added that Lebon had it in view to light up a great part of Paris with it. In consequence of this, we agreed that it would be proper to resume our experiments and bring the question of economy to a fair trial. Accordingly, these experiments were resumed in the course of the year 1802, and at the period when the peace took place, which, I believe, was in the spring of 1802, a public display of these lights was made in the illumination of Mr. Boulton's manufactory, which then took place. In 1803, we erected an apparatus for the purpose of giving a light to a part of our own works, and till 1804 we continued making experiments on the gas produced, and also on the different coals out of which the gas was to be made; on the manner of making the retorts best adapted to the purpose; upon the materials and construction of the pipes; upon the size and construction of the gasometers; upon the economy of different sorts of burners; and upon various other points which may escape me at this moment. The experiments were very long, and attended with a great deal of expense. We were out of pocket not less than £4000 or £5000, and are so at this moment for the experiments and machinery." This is a succinct narrative of the circumstances under which the development of Murdoch's invention was for some years delayed by the firm of Boulton & Watt, and eventually undertaken by them. It shows that it was fear of being anticipated by Lebon that quickened the firm's pace, and finally overcame their reluctance to embark in this new venture. Without Lebon, therefore, Murdoch's invention might have remained indefinitely in the background; but it may with equal justice be said that without Murdoch, Lebon's ideal could not have been realized. There is no evidence to show that either Murdoch or Lebon aimed at anything beyond a number of separate and independent installations; but Lebon's idea of "lighting a part of Paris with it" seems to have fired the imagination of his follower, Winsor, in whose hands a public supply of gas lighting became a reality, although this was only made practicable by the achievements of Murdoch, and the development of engineering and industrial art.

Unlike Murdoch, Philippe Lebon, called D'Humberson, to distinguish him from his brother, enjoyed the advantages of an education which may be called liberal. Born in 1767 at Brachay, near Joinville, Haute-Marne—his father being a retired officer of Louis XV.—he was sent to Paris for his education, and afterwards to Chalons-sur-Marne, where he applied himself chiefly to the study of mathematics and drawing. In 1787, being then twenty years of age, he was admitted to the École des Ponts et Chaussées, on leaving which he obtained the highest place in the examination, with the titular degree of major. Here he enjoyed the tuition of the celebrated engineer Prony, of whom he afterwards said, "to this ingenious master I owed my first successes, which gained for me the encouragement of Government; and if I have since that time made any useful discovery, it is to him my acknowledgments are due."

At twenty-five years of age—namely, in 1792—Lebon became an engineer of the Department of Bridges and Roads. By a decree dated the 18th April in the same year, he was presented with a National Reward of 2000 francs for improvements in "fire-," or as they were soon to be called, steam-engines, in connection with which he had when at school been awarded a prize. It is interesting to note his association, at this period, with a subject which also engaged much of Murdoch's attention, and upon which the latter was to leave enduring marks of his skill and ingenuity.

It is claimed that Lebon first directed his attention to the possibility of obtaining gas suitable for heating and lighting by submitting wood to calcination in a closed vessel, as far back as 1791. While on a visit to his father at Brachay, the idea is said to have occurred to him, and he then filled a glass phial with sawdust and placed it on the fire. He saw the smoke disengage itself, and that this took fire on the approach of a lighted candle. To make it suitable for lighting purposes he passed the outlet pipe of his phial into another phial filled with water, in which the "acid vapours and bituminous matters" were condensed, and the gas issued from this vessel "quite purified." Continuing his experiments, he built, in the yard of his father's house, a small furnace in which was placed a brick retort. In this retort wood was submitted to distillation, and from it a pipe conveyed the gas to a vat filled with water, in which was another vat inverted, to serve as a gasholder. At the outlet of this vat the gas having passed through the water was found to be sufficiently pure for use, and gave a brilliant light. In his enthusiasm at his discovery, Lebon is said to have declared to his friends that he would convey warmth and light from Paris to Brachay. His friends in return thought him mad.

Lebon seems to have communicated his ideas to Fourcroy, by whom he was encouraged to continue his researches. He took a house in the Ile de St. Louis, a quarter of Paris which had suffered greatly from the Revolution, and was at that time almost deserted; grass growing in the streets. The house occupied by Lebon was opposite l'hôtel de Bretonvilliers, in the rue St. Louis. Here he made his experiments on a large scale, and received visits and advice from Fourcroy, Prony, and other distinguished savants of the period. It may be inferred that illuminating gas was the subject of these experiments, but the first patent taken out by Lebon was for quite a different matter. This patent is dated 11th September, 1796, and is described as "Pour distiller au moyen du vide et du froid." In the same year he had, much to his regret, to remove from Paris, which he regarded as *l'incomparable foyer d'étude.* The École des Ponts et Chaussées, to which he had been attached, was greatly in need of funds, which the Republic could ill spare for its support. It was removed from the rue Lazare to less expensive quarters in the faubourg Saint-Germain, and the number of pupils was reduced, Lebon being transferred to Charente in Angoulême, to serve as an ordinary engineer. Here he fell under the displeasure of his superior officer for occupying himself with matters which seem to have interfered with the proper discharge of his duties; objection being also taken to his occasional visits to Paris, apparently for the purpose of continuing his researches. Application being made to the Minister of the Department for his removal to another and more

PHILIPPE LEBON.

remote district, Lebon defended himself by letter, in which he referred to the great importance of his discovery of inflammable gas produced by the distillation of wood. He was restored to his position ; but later we find him in great trouble owing to the impecuniosity of the Convention. It was the period of Napoleon's Italian campaign, and the Government could ill spare money for payment of salaries at home. In this extremity his wife proceeded to Paris, and made a spirited and apparently successful appeal to the Minister on his behalf. He was shortly afterwards re-transferred to Paris.

In 1799, Lebon sent to the National Institute an account of his invention for the production of heat and light, which, after the usual examination and inquiry had been made, resulted in his being granted a patent for the long term of fifteen years, dating from the 28th September, 1799.[1] The following is a copy of Lebon's Specification as deposited in the Patent Office in Paris, together with a facsimile of the drawing bearing his signature, which is attached thereto :

MOYENS NOUVEAUX D'EMPLOYER LES COMBUSTIBLES PLUS UTILEMENT ET À LA CHALEUR ET À LA LUMIÈRE ET D'EN RECUEILLIR LES DIVERS PRODUITS.

Brevet du 6 Vendémiaire An VIII (28th September, 1799).

Les recherches faites jusqu'à présent sur les fourneaux, poêles et lampes se sont bornées à nous donner les tuyaux et des réservoirs de chaleur, à activer et à proportionner le courant d'air nécessaire à la combustion et quelques autres dispositions avantageuses.

Mais jusqu'à présent nos moyens n'ont point offert séparément à notre disposition les diverses parties constituantes du combustible. Nous n'avons pu recueillir celles de ces parties qui étaient ou inutiles ou nuisibles à la combustion à la chaleur et à la lumière et qui pouvaient être précieuses pour d'autres usages. Parmi celles-ci on doit compter spécialement l'Acide pyroligneux contenu dans le bois et qui s'emploie avec avantage à former les chaux métalliques et diverses autres opérations. Nous n'avons pu offrir isolément à la combustion chacune de ces parties qui en était susceptible, régler une opération qui devenait trop compliquée, en coercer et recueillir les produits et obtenir des effets constants de lumière et de chaleur. Nous n'avons pu gouverner à tel point le principe qui produit et de la lumière et de la chaleur (le gaz inflammable ou hydrogène) que l'on put à son gré le recueillir, soit pour le destiner aux aérostats, soit pour tout autre usage, le distribuer, modifier le nombre et la forme de ses jets, l'enflammer et lui faire porter à toute distance du foyer la lumière et la chaleur.

Ces avantages que nous laissaient regretter nos méthodes, me sont aujourd'hui promis par les moyens que j'ai inventés et leur jouissance exclusive est l'objet du brevet d'invention que je réclame. Je vais donner la description

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[1] Amongst writers on this subject there exists some confusion of dates, but since the Republican year 1 dates from the 22nd September, 1792, the 6 Vendémiaire (1st Month) VIII must correspond with our 28th September, 1799.

de l'appareil propre à produire ces effets, mais je dois prévenir que je suis forcé de considérer la question sur le point de vue le plus général et que le nombre, les proportions, la forme, la figure, les positions respectives de toutes les parties de cet appareil sont autant de variables qui sont éventuellement subordonnées aux divers buts ou applications qu'on peut avoir en vue.

La figure représente une coupe générale de l'appareil. Un vaisseau V porte sur l'un de ses fonds deux bouts de tuyaux T & T′ par lesquels on peut introduire ou tirer le combustible et qui se ferment exactement.

Un troisième tuyau T″ adapté au même fond est destiné à conduire les vapeurs et les gaz qui se dégagent du combustible contenu dans le vaisseau V. L'autre fond de ce vaisseau V est percé pour recevoir et se lier au fourneau F qui s'étend dans l'intérieur du vaisseau V et seulement à son extérieur de l'épaisseur de la cheminée C.

Un diaphragme D partage le fourneau F et s'étend de l'ouverture vers le fond de manière à laisser entre son extrémité et le fond du fourneau un libre passage à l'air.

La cheminée (C) qui part du fourneau se prolonge jusqu'au dessus du vaisseau V qu'elle enveloppe de plusieurs révolutions avant de se terminer par le tuyau T‴. Toutes ces parties sont renfermées dans une enveloppe de matiére et d'épaisseur convenable à laisser plus ou moins dégager ou coercer la chaleur. Au moyen du tuyau T″ on peut conduire, distribuer les gaz et vapeurs, les obliger à traverser tel nombre de condenseurs et bains qu'on jugera convenable, les. soumettre à tous les moyens connus de purification et d'analyse, recueillir les divers produits, en un mot disposer à son gré de ces gaz ou vapeurs.

L'ouverture (O) sert à charger de charbon de terre le dessus du diaphragme (D) ; elle s'ouvre et se ferme à volonté, celle o′ sert également à introduire du charbon dans les parties inférieures du fourneau et pour le passage de l'air qui doit alimenter la combustion du charbon contenu dans ce fourneau F. Tout étant ainsi disposé, si on allume le charbon du fourneau F, considérons ce qui doit se passer dans le vaisseau V rempli du combustible que nous supposons être du bois, les effets sont analogues pour le charbon de terre, les huiles, les résines, les graisses et autres combustibles.

Pour l'action de la chaleur dans l'intérieur du fourneau F et à l'extérieur du vaisseau V il se dégage une abondance considérable de vapeur et de gaz ; on obtient spécialement une grande quantité de gaz hydrogène dans un état de pureté plus ou moins grands suivant les moyens employés pour le purifier.

Les vapeurs se réduisent à l'état de fluide en les exposant au froid du condenseur et produisent des acides, de l'huile et divers produits analogues aux combustibles employés dans le vaisseau V. Ceuxci se réduisent en charbon et peuvent successivement passer dans le fourneau F pour opérer par leur combustion sur de nouveaux combustibles les mêmes effets qu'ils ont éprouvés.

A Paris, le 17 Fructidor An VII (September 3rd, 1799).

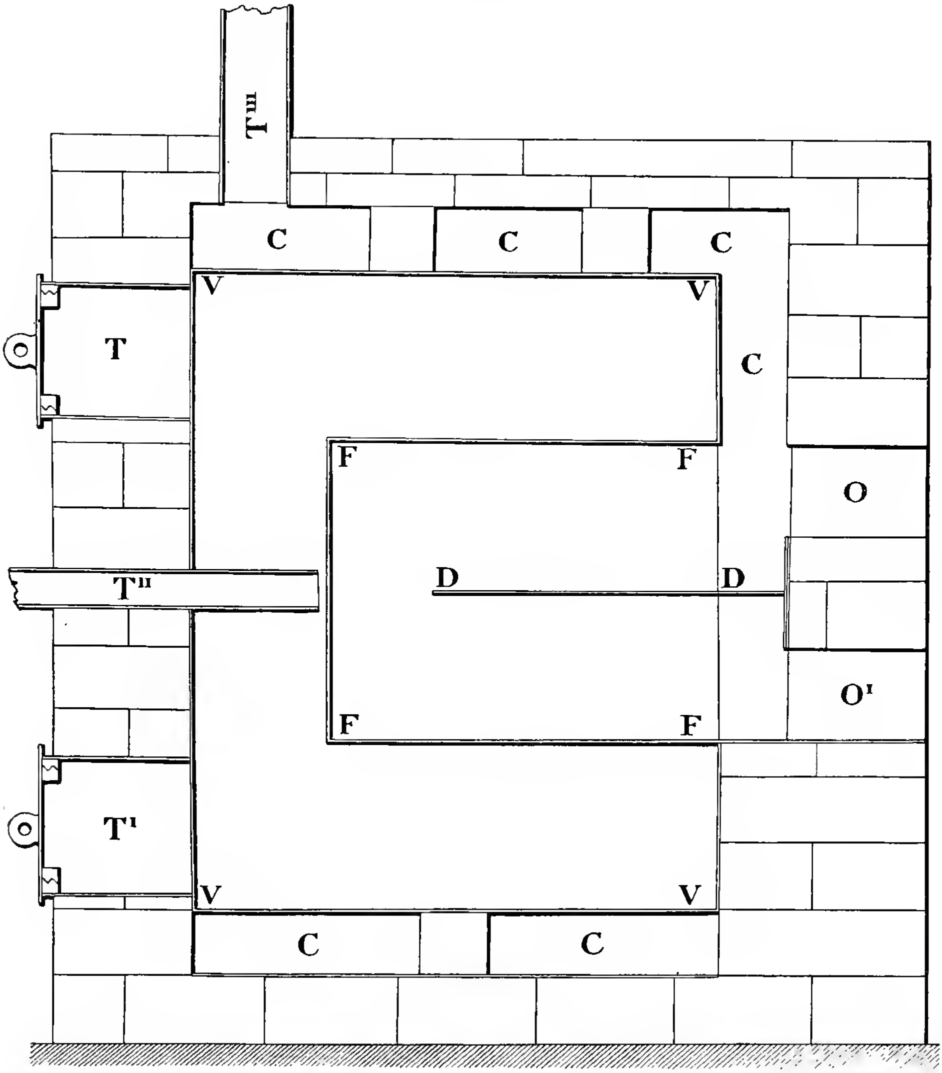
LEBON.

In this specification Lebon confines himself to the means to be employed for producing inflammable gas by the distillation of wood and other substances, including coal. As to the gas itself, it is merely observed that by means of the pipe T″ this can be conducted and distributed through any desirable number of condensers or receptacles, to subject it to all known processes of purification and analysis, to collect the various products, and, in short, to dispose of it at will. The title, however, clearly indicates that the gas may be used for both heating and lighting ; and such uses are enlarged upon by Lebon in a popular description of his invention, which he published in the form of a prospectus in August, 1801. This description was made more widely known by its republication in 1802 in three languages—English, French, and German—by Frederick Albert Winsor, who dedicated it to the Duke of Brunswick, " as Protector, Judge, and Lover of Arts and Sciences." In it Lebon refers to the possibility of conducting the gas through the smallest pipes or in chimneys of 1 inch square fixed in the plaster of walls or ceilings, and even in tubes of oiled silk, if the extremities where combustion takes place are of metal only. " A single stove may thus supersede all the chimneys of a house, the inflammable gas from it being conveyed everywhere to give the most sensible heat and the softest light." . . . " Soft and pure," he goes on to say, " this light may be moulded into every shape, into flowers, festoons, &c., every form suiting the flame, which may descend from a ceiling in the shape of a chalice of flowers, and spread above our heads a clear light not masked or shaded by any support whatever, darkened by no wicks, or tarnished by the least black or smoke. Its natural colour being white, may also be varied and become red, blue or yellow ; hence this variety of colours which mere chance produces in our chimneys and stoves, may here become the constant effect of art and calculation." There is a touch of Diller in this ; Lebon had doubtless heard of him, and may have seen his exhibition. " We may easily judge," he proceeds, " that with an inflammable principle so very docile and active we can produce the most magnificent illuminations. Streams of fire well disposed—their durability, colour and form changing at pleasure : the movements of suns and columns must produce the most wonderful effects." He is not, however, unmindful of more useful purposes. " Who," he says, " would not be charmed with the service of a flame so very complaisant ; willing to boil and roast our victuals ; our cooks no longer being exposed to the fumes of charcoal ; and those victuals it is ready to keep warm on our tables. It dries our clothes and linen and warms our baths."

The apparatus by means of which these desirable objects were to be achieved was a crude contrivance, although it appears to have answered sufficiently well to demonstrate the process which Lebon desired to establish. It will be seen from the illustration, p. 55, that the chamber V V V V, which served as the retort, was fed through the aperture T, and discharged through T′, the gas issuing at T″. F F F F is the furnace, probably

* Coupe generale de L'appareil dont jai donné la description par un memoire remis cejourd'hui au Secrétariat du Dept de la Seine à L'effet d'obtenir un Brevet d'invention de quinze années à Paris le Dix Sept Fructidor an Sept

Lebon



made of sheet iron, which had a plate D D instead of firebars, on which the fuel was placed through the furnace door O; the lower door O′ serving for the introduction of coal into the lower part of the furnace, and of air for maintaining the combustion of the coal in the furnace. The products of combustion passed to the chimney T‴ by way of the flue C C C C C C.

A "Certificat d'Addition" to this patent was granted to Lebon under date 7th Fructidor An IX (24th August, 1801). This is entitled "Developpement des vues et moyens proposés pour employer plus utilement les combustibles et consigné dans un brevet d'invention accordé au soussigné le 6 Vendémiaire An VIII sur sa pétition en date du 17 Fructidor An VII." It is a lengthy document, and is mainly occupied with the proposals of the inventor for obtaining motive power from his inflammable gas. He explains with great accuracy, considering the state of knowledge at the time, the phenomena of the combustion of gas, and the expansive force which is developed thereby; stating, however, that ammonia is formed by the combination during combustion of the hydrogen of the gas with the nitrogen of the atmosphere. A drawing shows the apparatus by which this expansive force was to be utilized, and the inventor suggests that an electric spark should be employed for firing the mixture of air and gas; a device for which a patent was taken out many years afterwards.

This proposal of Lebon's was, in effect, an anticipation of the modern gas engine. There were, however, earlier ones. In 1791, patents were taken out by Thomas Mead and John Barber; the former for "Reciprocating fire or steam-engines, for use in pumps, mills, cranes, carriages and other purposes where the force of fire or steam is required"; and the latter for "Procuring motion, and facilitating metallurgical operations, by inflammable air." Another patent was taken out by Mead in 1794, and also one in the same year by Robert Street, both for the production of power and motion sufficient to drive machinery, by means of inflammable vapour, or the decomposition of permanently elastic fluids. In this specification Lebon also points out that in ironworks inflammable gases are neglected and lost, which nevertheless are capable of producing heat and motion; foreseeing thus the utilization of blast-furnace gases, an industrial economy which has been successfully accomplished during the last few years by Mr. B. H. Thwaite and others.

Anticipating objection to the escape into an apartment of the products of combustion, Lebon concludes by describing a means by which these may be removed. He says: "If the gas for lighting is carefully prepared and cleansed, it possesses none of the inconveniences of the oil, tallow or wax employed by us for lighting, and lest it should be regarded as an evil it would be well to note the ease with which the light and heat can be radiated throughout an apartment, while all other products can be led away outside, including the products of combustion. The following is my invention for the attainment of this object:

"The combustion of the inflammable gas takes place within a glass globe supported upon a tripod and cemented in such a manner as to allow none of the products to escape. The gas is conveyed in a small tube, the atmospheric air being admitted through a second tube, while a third tube leads off the products of combustion. The tube through which the air passes may draw its supply either from within or without the room, according as it is desired to renew the air in the room or not. Since the tubes unite below the globe, it is necessary that that conveying the air supply should rise vertically throughout a part of its length, and that it should be slightly warmed at the beginning, in order to induce the draught. Each tube should be provided with a tap or valve, by means of which the gas and air supply can be regulated as desired.

"It will be understood without explanation that the globe may be suspended from a ceiling, and that in all cases it is easy to give prompt and immediate effect to the combination of the two elements of combustion, to distribute the luminous globes and shape them as desired, to control at will the operation of combustion, and finally to obtain light and heat through the protective medium of the glass, without risk from the effects of foul air or metallic vapours. Moreover, it is not always necessary, in order to get rid of the products, that combustion should take place in a hermetically sealed globe. A small dome or shade of glass, porcelain, or other material, could equally well receive them and collect them in a tube through which they would be drawn off continually by the action of the draught."

In this specification mention is made, apparently for the first time, of the name "Thermolamp," "by which," says Lebon, "some people have been pleased to call my apparatus." It occurs also in the prospectus or description from which we have already quoted, and which was published to announce Lebon's discovery, and the exhibition of it in the winter of 1801–2. With an accent of sincerity revealing the strength of his conviction, Lebon commences the description by stating the difficulty he felt in announcing facts so extraordinary that those who had not witnessed his demonstration of them exclaimed against their possibility; and also that he would rather give up all idea of his invention than that it should have the appearance of mystery and charlatanism. The pamphlet concludes by offering to the public this invention, which had only been secured "after numerous sacrifices." "It is," says Lebon, "with the expenditure of my patrimony that I have defrayed so many essays and experiments. I shall open a subscription for the acquisition of my Thermolamp; but although this may be my principal purpose, it shall only begin from the moment public opinion is decided, and calls for the same. Consequently my house shall be open every Decade. It would certainly be impossible to offer in one assembly all the effects I have obtained in the course of several years." The exhibition was, therefore, to be varied from time to time, and as "very powerful reasons" did not permit of his making gratuitous experiments, and it was also desirable to prevent overcrowding, the price of admission was fixed at 3 francs, with the understanding that the numbers admitted would be regulated " to the extent of the place."

This exhibition was held in a house called l'hôtel Seignelay, in the rue St. Dominique, Saint-Germain. Here a workshop was erected for the accommodation of a " huge " Thermolamp, from which was distributed light and heat throughout the house, the garden being also decorated with gas jets forming various devices, such as roses and garlands. There was also a fountain illuminated by gas jets, water being made to flow from urns in the midst of the flames. According to Winsor, this exhibition " was seen by thousands with the greatest astonishment," and in his introduction to Lebon's description he mentions that he was induced by the fame of the discovery to travel from Frankfort to Paris, where he often witnessed the wonderful effects of *common smoke being made to burn with greater beauty than wax or oil.*" In the spring of 1802, he negotiated with Lebon, through the medium of M. Charles Pougens, a member of the National Institute of France, for the purchase of a Thermolamp under, he says, " every restriction of not making any public use of the same." He was, however, unsuccessful ; Lebon declining, according to the correspondence published by Winsor, to dispose of any Thermolamp until a subscription for 200 had been completed, when the price would be from 1000 to 1200 livres.

Winsor accordingly left Paris on the 3rd April 1802, " without hopes to satisfy my curiosity, but having assisted some experiments of Lebon and seen his whole apparatus, I made several trials on the chemical procedure, and succeeded in the practice."

Lebon did not obtain his subscription for 200 Thermolamps, nor, if Winsor is to be credited, did he " much care whether it was ever filled, as he was then in treaty with the Government for manufacturing tar for the French marine." The fact appears to be that the spectacle did not impress those who saw it as being of much practical importance. Interesting it undoubtedly was ; but the unpleasant odour arising from the combustion of unpurified gas did not commend the process as one that could come into general use. But the brilliancy and ingenuity of the experiment was generally recognized. After the exhibition at l'hôtel Seignelay, the inventor was invited to a public séance at the Atheneum of Arts " pour être présent aux témoignages d'estime que la Société voulait rendre á ses travaux." The Minister of Marine appointed a Committee to examine and report upon the process, with the view of ascertaining its practicability for the production of tar, of which the French navy was at that time in great want. In the result, Lebon was granted, in September, 1803, a concession over a large part of the pine forest of Rouvray, near Havre. Here he established a tar factory, one condition of the concession being that he should produce 5 quintals, *i.e.* 500 lbs., of tar daily. It is said that he was assisted in this venture by some Englishmen, who had been attracted to France by the Peace of Amiens, and had remained in the country after the renewal of the war.

PHILIPPE LEBON (1767-1804)

STATUE OF LEBON ERECTED AT CHAUMONT.

Here Lebon was twice visited by the Russian Princes Galatzin and Dolgorouki, who proposed to him in the name of their Government that he should go to Russia and work his process there, on his own terms. This offer was declined, Lebon preferring to give his own country the benefit of his process. His life at Rouvray was, however, chequered by misfortune. At one time, his humble dwelling was unroofed by a gale; at another, fire destroyed a part of his factory. He was, however, on the way to prosperity when he came to an untimely and tragic end. Being still on the roll of engineers of the Department of Roads and Bridges, he was summoned to Paris to assist at the coronation of Napoleon as Emperor on the 2nd December, 1804. On the following morning, his lifeless body, pierced by the dagger of an assassin, was found in the Champs Elysées, the scene in after years of many brilliant gaslight illuminations. The perpetrator of this foul deed was never brought to light. Thus perished miserably this accomplished Frenchman, who, if wanting in some of the qualities that command success, was yet capable of pointing out the way by which a notable advance might be achieved. Before the close of the century which witnessed an extension of gas lighting all over the world, such as he in his most sanguine moments could not have anticipated, his admiring countrymen erected a monument to his memory and honour. This took the form of a statue of himself, and stands in the market town of Chaumont, near which is the village in which he was born. It was inaugurated with much ceremony on the 26th June, 1887, in the presence of a large and distinguished company, including descendants of the Lebon family.

Although it is stated by Winsor that "repeated and considerable offers were made to Lebon from the Theatres and public gardens in Paris, and from one American gentleman, bidding him 3000 louis d'ors for his invention," no practical use was ever made of the Thermolamp for the production of illuminating gas. But it was revived for the purpose of exhibition seven years after Lebon's death by his widow, who was unable to carry on the tar factory, owing partly to the dishonesty of a subordinate, and partly to a falling off in the demand for tar in consequence of the destruction of the naval power of France at Trafalgar. Madame Lebon, in 1811, exhibited the Thermolamp in a house in the Rue de Bercy, Faubourg Saint-Antoine. This appears to have attracted considerable attention, and a prize of 1200 francs was awarded to her by the Société d'encouragement pour l'industrie nationale, for her description of experiments made in the distillation of wood, and the products derived therefrom. It was announced on behalf of the Société that in making this award they were influenced by the fact that in a great number of English factories the economical process of employing for lighting purposes the gas produced by the distillation of coal had been applied; thus carrying out the happy idea which, according to them, originated with Lebon. Also that this process was in course of being adopted for lighting the streets of London; and that, as it had already been brought to the highest degree of perfection, it was necessary to apply it in France as it had already been applied in England.

In proclaiming Lebon as the original inventor of the process, it was decided to memorialize the Government on behalf of Madame Lebon; the result being that a pension for life of 1200 francs per annum was granted her. She died, however, in 1813, only two years afterwards.

NOTE.—For further particulars of the life of Lebon, the reader may be referred to the little work by Baron Ernouf, entitled *Les Inventeurs du Gaz et de la Photographie*, published by Hachette & Co., Paris, in 1877, and also to the *Merveilles de la Science*, by Louis Figuier, an extract from which, entitled " Notice Historique sur Philippe Lebon." was published in pamphlet form by the Committee appointed for the erection of a statue to Lebon, in 1882.

CHAPTER III.

MURDOCH, CLEGG, AND OTHERS.

AS will have been seen from the evidence of James Watt, junior, quoted in the previous chapter, coal gas was used experimentally for lighting a part of Soho Foundry in 1798. Nothing more was, however, done with the invention until towards the close of 1801, when, stimulated by the news from Paris of Lebon's exhibition, the experiments were resumed ; the first result of these being a public display of gas lighting at the Soho Works on the occasion of the celebration of the short-lived Peace of Amiens, early in the following year. William Matthews, in the preface to his *Historical Sketch of the Origin, Progress, and Present State of Gas Lighting,* which was published in 1827, says of this display that " he had the inexpressible gratification of witnessing, in 1802, Mr. Murdock's extraordinary and splendid exhibition of Gas-Lights at Soho. This remarkable illumination was the first public display of the kind in this country, and at the time produced a very strong impression upon the inhabitants of that populous town," meaning Birmingham, where he was staying at the time. Elsewhere (p. 23) he says : " The illumination of Soho Works on this occasion was one of extraordinary splendour. The whole front of that extensive range of buildings was ornamented with a great variety of devices, that admirably displayed many of the varied forms of which gas light was susceptible. This luminous spectacle was as novel as it was astonishing ; and Birmingham poured forth its numerous population to gaze at and to admire this wonderful display of the combined effects of science and art." In a footnote he repeats that he was an eye-witness of this illumination, and adds that " Mr. Murdock was assisted in his experiments at Soho by Mr. Southern and Mr. Henry Creighton, both of whom were men of talent and information."

In the account, however, which was given of this notable display by the Press of the period, there is no mention made of gas. Aris's *Birmingham Gazette* was at the time the local organ, and in the issue for 15th April, 1802, reference is made to these illuminations, " which," it is stated, " for elegance and boldness of design, grandeur of effect, and promptness of execution, will remain unequalled amongst the numerous testimonies of joy displayed on the happy occasion of returning peace. The well-known taste and abilities of the liberal proprietors of those premises had given the public every reason to anticipate a very superb and brilliant exhibition; and accordingly early in the afternoon the road from the town was crowded with passengers. The gates of the gardens were thrown open, and gave admittance to many thousands of spectators, of whom it is but justice to observe, that they departed almost without breaking either shrub or tree, or doing any damage. The house was adorned on the summit of the roof by a magnificent star, composed of variegated lamps, and the centre window was embellished by a beautiful transparency, in glass, of a female figure, in the attitude of offering a thanksgiving for the return of peace. The manufactory was illuminated throughout its spacious front with upwards of 2000 coloured lamps, disposed into the form of G. R., with the word 'Peace,' above which was placed the crown, with a star of excellent brilliancy. In the centre of the front, a transparency represented a dove, the emblem of peace, descending on the globe; on the left wing, another represented the Caduceus of Mercury between two Cornucopias; and on the right, a beehive decorated with flowers. In addition to the above, three very splendid Montgolfier Balloons ascended in succession from the courtyard within the Manufactory at proper intervals, on a signal from the discharge of cannon. Numbers of sky rockets also tended to enrich the scene. The whole gave the greatest satisfaction, and produced, in the minds of the spectators, tokens of admiration and sentiments of respect for the magnificent proprietor. Every house in the neighbourhood was also splendidly illuminated; and all the workmen belonging to the manufactory were regaled at public-houses (!)" The excellence of the display that was made at Soho on this occasion, admits, from this description, of no question; but that gas was employed to produce it was not publicly announced until three years afterwards, when it was noticed in the letter to Dr. Henry, already referred to.[1] It is there stated that the "new lights" were made to constitute a principal feature of these illuminations. The silence of contemporary writers on the subject has given rise to a considerable amount of controversy as to whether or not gas was really employed on this occasion. There is, however, no room for doubt upon this point, having regard not only to the letter above referred to, but also to the evidence of James Watt, junior, before the Committee of the House of Commons in 1809, and which was quoted in the last chapter. In the course of this evidence, Watt says that "at the period when the peace took place . . . a public display of these lights was made in the illumination of Mr. Boulton's manufactory which then took place." Murdoch himself, also, in the account which he gave of his invention to the Royal Society in 1808, which will be hereafter referred to, states that at the peace of 1802, "a public display of this light was made by me in the illumination of Mr. Boulton's manufactory at Soho, upon that occasion." The only question at issue seems, then, to be, to what extent was it used? A correspondent, L. L., who contributed to the *Mechanics Magazine* in 1834, "Materials for a Memoir of Mr. Samuel Clegg, and Authentic History of the Art of Gas Lighting,"[1] states that "Mr. Clegg's attention was first directed to the practicability of distilling gas from coal when assisting to illuminate the Soho manufactory. The gas was not displayed, upon that occasion, in any devices on the front of the manufactory, as stated by some writers upon gas-light illumination. The apparatus, if such it could be called, consisted simply of a retort, set in the fireplace of one of the houses at the corner of the manufactory, a pipe from which was conveyed up the chimney, and terminated in a copper vase. When the gas, &c., came over in sufficient abundance it was ignited, and this was called a Bengal light; there was one at each extremity of the manufactory." This statement was traversed by Matthews in a letter to the *Mechanics Magazine*, dated 14th April, 1835,[2] in the course of which he says that "what I have stated was from being a spectator of the illumination; and in a conversation with Mr. Clegg concerning it a few years ago, he told me that he actually constructed the device, forming a crown on the cupola of the establishment. L. L.'s description of the apparatus employed is altogether erroneous. The retorts to produce the gas were placed in the upper room of the building; and Mr. Murdock is my authority for the statement." Samuel Clegg, junior, however, in his *Treatise on the Manufacture of Coal Gas*, the first edition of which was published in 1841, practically reiterates—doubtless on the authority of his father—the statement of L. L. He says on p. 6: "In March, 1802, on the occasion of the general illumination for the peace of Amiens, Mr. Murdoch publicly exhibited the gas light, by placing at each end of the Soho manufactory what was termed a Bengal light. The operation was effected by fixing a retort in the fireplace of the house below, and then conducting the gas into a copper vase. This was the only gas used on that occasion; the rest of the manufactory being illuminated by the usual small glass oil lamps, and not with gas as has been erroneously stated." In a footnote it is further stated that "Mr. Clegg, then a pupil of Messrs. Boulton, Watt, & Co., was present and assisted at this illumination." It has been suggested that Clegg, having been in after-years a rival of Murdoch's in the development of gas lighting, sought to minimize what was done upon this occasion; but it must be said that all the probabilities point to the correctness of his statement. The silence of the contemporary Press on the subject; the fact that the art of gas lighting was then in its very infancy, the experiments with regard to it having been renewed only a few months previously; and the absence of a gasholder, without the assistance of which any such general illumination as that which is described could hardly have been possible; all serve to show that the early historian of gas lighting was mistaken in ascribing to coal gas the effects which impressed him so greatly a quarter of a century previous to the publication of his account of them. In fact, there was a description of these illuminations written in the year 1814, when, at the conclusion of the peace of that year, they appear to have been repeated, which makes it additionally clear that the effects were produced by oil lamps of various colours. This description was published in the form of a handbill, a copy of which is, or was a few years ago, in the possession of a citizen of Birmingham—Mr. Thomas Knott, junior, from which it appears that the building which was illuminated was " full 180 feet in length and about 55 feet high." The statement by Clegg as to the way in which gas was used on this occasion may therefore be accepted as the most likely version. A retort [1] fixed in a fireplace below yielded gas which was conveyed up to the top corners of the building, and there burnt in the form of a Bengal light. Without a gasholder, by which means the supply could be regulated, this could only afford a fitful illumination; and it is not improbable that, as has been suggested, the silence of the reporters on this subject may have been due to the exhaustion of the supply at the time that they arrived upon the scene. The demonstration must in any case have been somewhat crude, and scarcely such as to attract attention by reason of the novelty of its source. At the same time it does appear strange that Boulton should have taken no pains to publish the fact that a portion of the illumination was produced by gas.

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[1] P. 42.

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[1] *Mechanics Magazine*, vol. xxii. pp. 470–2.

[2] *Ibid.* vol. xxiii. p. 59.

That Matthews' account of the part played by coal gas on this occasion is inconsistent with the state of knowledge of the art of gas lighting which existed at Soho at that time, is further evidenced by the fact that it was only in the following year—namely, in 1803—that apparatus was applied to light a part of the Soho works; while, until 1804, experiments continued to be made upon all matters relating both to the manufacture and application of gas. Nor was it until 1807—five years afterwards—that the now historical installation of the new light at the cotton mill of Messrs. Phillips & Lee, of Manchester, was completed, although the house of one of the partners, Mr. Lee, had been previously lighted up. In the meantime the advantages of the new light had begun to be recognized, and others had started to manufacture the apparatus for its production. The following occurs in a letter which was addressed by Murdoch from Manchester on the 23rd December, 1805, to Messrs. Boulton & Watt, at Soho: " Gibson has finished his job at Macclesfield (which answers very well), and he is this day arrived at Manchester, where he must remain idle till I receive an answer from you, as none of Mr. Lee's lighting apparatus is yet arrived. . . . Please to let me know if the second receiver is sent off by land or by water; if materials cannot be forwarded in a more expeditious way than they have hitherto been done, it is of no use to think of taking orders here, for your old servant Clegg is manufacturing them in a more speedy manner than it appears can be done at Soho." There is also a letter from James Watt to Matthew Boulton, Soho, and dated Glasgow, 12th November, 1805, which indicates the position there of the new industry which Murdoch's invention had created. " The new lights " (says the letter) " are much in vogue here; many have attempted them, and some have succeeded

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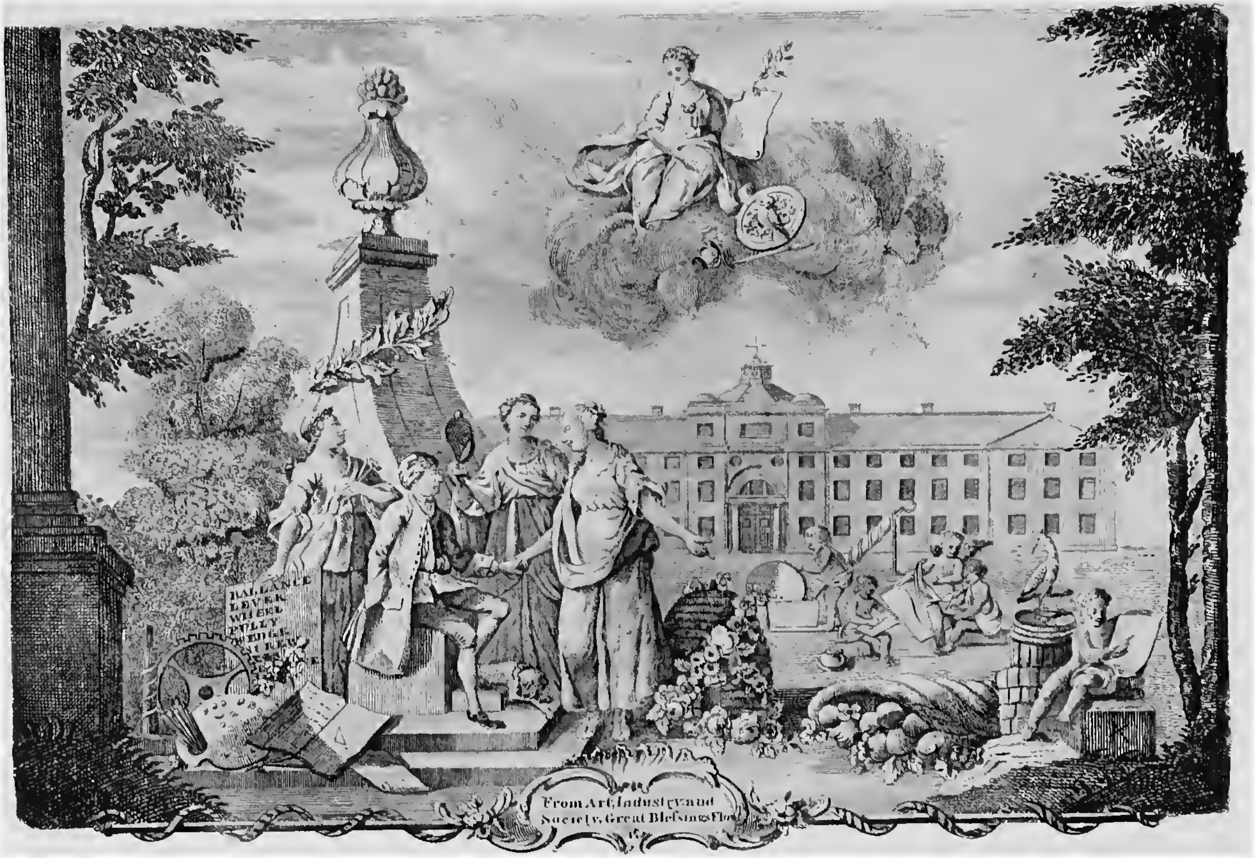
[1] The first retorts were only of sufficient size to contain about 15 lbs. of coal, but more than one may have been used on this occasion.



PRINT SHOWING FRONT OF THE SOHO WORKS, WHICH WERE ILLUMINATED, PARTLY WITH GAS, IN 1802.

tolerably in the lighting their shops with them. A long account of them was published in the newspapers some time ago, in which they had the candour to ascribe the invention to Mr. Murdock. From what I have heard respecting these attempts, I think there is full room for the Soho improvements, though when they once see one properly executed it will have numerous imitations." This letter was quoted in a paper on "Gas Lighting" read before the Glasgow Architectural Society on the 18th March, 1867, by William Johnston, and which also contains some interesting particulars relating to the introduction of gas lighting in the North, and the primitive arrangements that were then in use. It says: "The first shop lighted up with gas in Glasgow was that of Mr. Lumsden, bookseller (grandfather of our present Lord Provost). His small retort placed in the fire had no immediate apparatus—the gas went direct to the window by a pipe joined to the retort; when gas came it had to be lighted, whether daylight was gone or not, and had to continue until the charge of coal was exhausted." Of a later installation the author of the paper says: "Messrs. Hart had an improvement upon Mr. Lumsden's plan, by having a gasholder exactly on the plan of those now in use, but of a different material. It consisted of two tubs or barrels, one tub sunk in the floor, to hold the water, the other to hold the gas suspended mouth downwards, of course by a rope over a pulley fixed under their table in the back shop. Their gas pipes were, I think, made of tinned plate, and their burners made of glass tubes, the end of which was drawn out by the heat of the blow-pipe, the taper part broken off until the desired aperture was obtained." This apparatus is stated to have been in use seven years before the "Old" Gas Company had their gas introduced into Glasgow, which was in the year 1817, "and then the Messrs. Hart discontinued to manufacture their own, and made a connection with the Company's mains and their original fittings." It seems, also, that the first introduction of gas lighting into what the author of the paper calls "public works" in the neighbourhood of Glasgow, was in 1807, when a weaving shed at Pollokshaws was lighted with gas. There "the gas retort was the old cylinder of a steam-engine, 6 feet by 20 inches, which towards lighting time was heated to a bright red, the coals pitched in, and the old cylinder lid bolted on. The gas was first led into a fixed iron vessel in a large cask of water, whence it passed by pipes direct to the looms in the factory. The sort of burners, if any, are not mentioned; but the flames, 6 to 9 inches long, entirely eclipsed the light of the oil lamps. To clear the pipe from coal tar, &c., the steam was blown through them at stated times."

In the year 1805, an account appeared in the *Monthly Magazine* for April, of an experiment made by Mr. Northern, of Leeds, for applying coal gas for the purpose of producing light as a substitute for candles. He describes the mode in which he distilled coal in a retort, and collected the gas in a pneumatic apparatus; the retort used being a refiner's crucible, the top of which, after filling with coal, was closed with a metal cover, luted with clay, and having a metal pipe soldered into it for conveying the gas into a pneumatic trough.

He concludes his account with an expression of his "great hopes that some active mechanic or chemist will, in the end, hit on a plan to produce light for large factories and other purposes at a much less expense, by the above or similar means, than is at present produced from oil."

The hope thus expressed by the writer was at that very time in course of actual fulfilment. Only a few months later Murdoch was waiting at Manchester for "Mr. Lee's lighting apparatus," and Boulton & Watt's "old servant Clegg" was also manufacturing apparatus of this description. Clegg, in fact, erected in 1805, as stated by himself in his account of his inventions, "a gas apparatus at the cotton mill of Henry Lodge, Esq., near Halifax, which was the first in the Kingdom. In 1806, I lighted his dwelling-house, where I first attempted to purify the gas by lime introduced into the tank in which the gasometer floated." Moreover, as was pointed out by Dr. Henry, in reply to Northern's letter, the new light had already been exhibited at one of the public places of amusement in London (the Lyceum Theatre). Dr. Henry, however, claimed for Murdoch the honour of the discovery, stating that "the extensive iron factory and compting house of Messrs. Boulton & Watt, near Soho, have been for some time regularly lighted in this mode;" and also that "by the information I had obtained at Soho, I was enabled in a course of chemical lectures last winter" (1804–5) "to exhibit the Argand's lamp on Mr. Murdock's plan; and was induced, by the beauty of the light which it yielded, to examine attentively the composition of gas from coal, with a view to ascertain in what it differs from pure hydrogen gas, carburetted hydrogen gas, and the carbonous oxide, all which, when burned in an Argand's lamp, give comparatively very little light, and are entirely unfit for the purpose of illumination." These experiments, which extended to the distillation of wood, peat, oil, wax, &c., "with a view to the theory of their combustion, when employed as sources of artificial light," formed the subject of a paper which was published in Nicholson's *Journal* for June, 1805 (pp. 65–74), the postscript to which was referred to in the previous chapter. They were followed up by others, which were communicated to the Royal Society in 1808 (pp. 282–303). These two papers, and the exhibition of gas lighting by Dr. Henry in the course of his lectures, attracted the attention of the scientific world to this invention, further research work in connection with which formed the subject of additional communications made by Dr. Henry to the Royal Society in the years 1820 and 1824. Dr. Henry was the first chemist of repute who made careful analyses of the composition of coal gas, and investigated its properties. He is credited with having been the first to suggest the use of lime for purification, but his title to this is not quite clear. In his communication to the Royal Society in 1808 he does state (p. 302) that "the only effectual method of purifying the coal gas from sulphuretted hydrogen on the large scale of manufacture, will probably be found to consist in agitation with quicklime and water, composing a mixture of the consistence of cream;" but Clegg, as already mentioned, claimed to have used lime in 1806, and in the same year

DR. WM. HENRY, F.R.S.

From the Bust in possession of the Manchester Literary and Philosophical Society.
Photographed by permission of that Society.

Edward Heard patented its use "stratified" with the coals in the retorts, in much the same way as Cooper proposed to employ it three-quarters of a century later—namely, in 1882. Lime appears, in fact, to have been generally recognized, almost from the first, as the most suitable material for purification, the only question being as to the mode of its application.

In the year following Clegg's first essay—namely, in 1806—Josiah Pemberton, of Birmingham, who had previously been constructing gas apparatus, exhibited gas lights in a variety of forms in front of his manufactory. His apparatus is stated to have consisted of a cast-iron pot holding about 15 to 30 lbs. of coal, set in brickwork like a common boiler. This had a strong cover of the same metal fitted on the top, to which was attached the pipe that conveyed the gas, as it was produced, to a square cistern containing water. This cistern was divided by several partitions, so adjusted that the gas had to ascend and descend in its passage through the water. It was thus condensed and washed before reaching the gasometer, which was suspended in a large wooden vat, and fitted with a counterpoise or weight to reduce the pressure. According to Matthews, the pipes by which the gas was conveyed to the burners were made of tinned iron or copper, and the burners varied as they were intended for lighting or for soldering. The first apparatus erected by Pemberton in the way of business was for a button manufacturer; and it is interesting to note that the gas was used, even in those early days, not only for lighting, but also for heating, the particular object of its use in this connection being for soldering the shanks of buttons. It is well known that in later years gas came very largely into use in connection with the various industries of this important manufacturing centre.

Murdoch's own achievements in these first years of the application of gas lighting are best described in his own language. In 1808 he communicated an account of them to the Royal Society, which was published in the *Transactions* for that year (pp. 124–132), and for which Count Rumford's gold medal was awarded to him. The communication is as follows:

AN ACCOUNT OF THE APPLICATION OF THE GAS FROM COAL TO ECONOMICAL PURPOSES. BY MR. WILLIAM MURDOCH. COMMUNICATED BY THE RIGHT HON. SIR JOSEPH BANKS, BART., K.B., *P*.R.S.

Read February 25th, 1808.

"The facts and results intended to be communicated in this Paper, are founded upon observations made, during the present winter, at the cotton manufactory of Messrs. Phillips & Lee at Manchester, where the light obtained by the combustion of gas from coal is used upon a very large scale; the apparatus for its production and application having been prepared by me at the works of Messrs. Boulton, Watt, & Co., at Soho.

"The whole of the rooms of this Cotton Mill,[1] which is, I believe, the most extensive in the United Kingdom, as well as its counting-houses and store rooms, and the adjacent dwelling-house of Mr. Lee, are lighted with the gas from coal. The total quantity of light used during the hours of burning has been ascertained, by a comparison of shadows, to be about equal to the light which 2500 mould candles of six in the pound would give, each of the candles with which the comparison was made consuming at the rate of 4-10ths of an ounce (175 grains) of tallow per hour.

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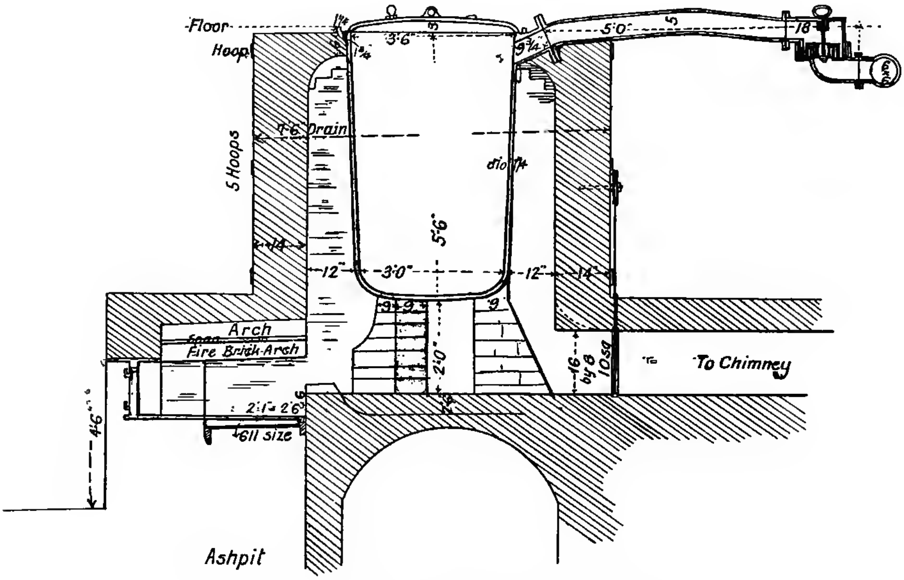
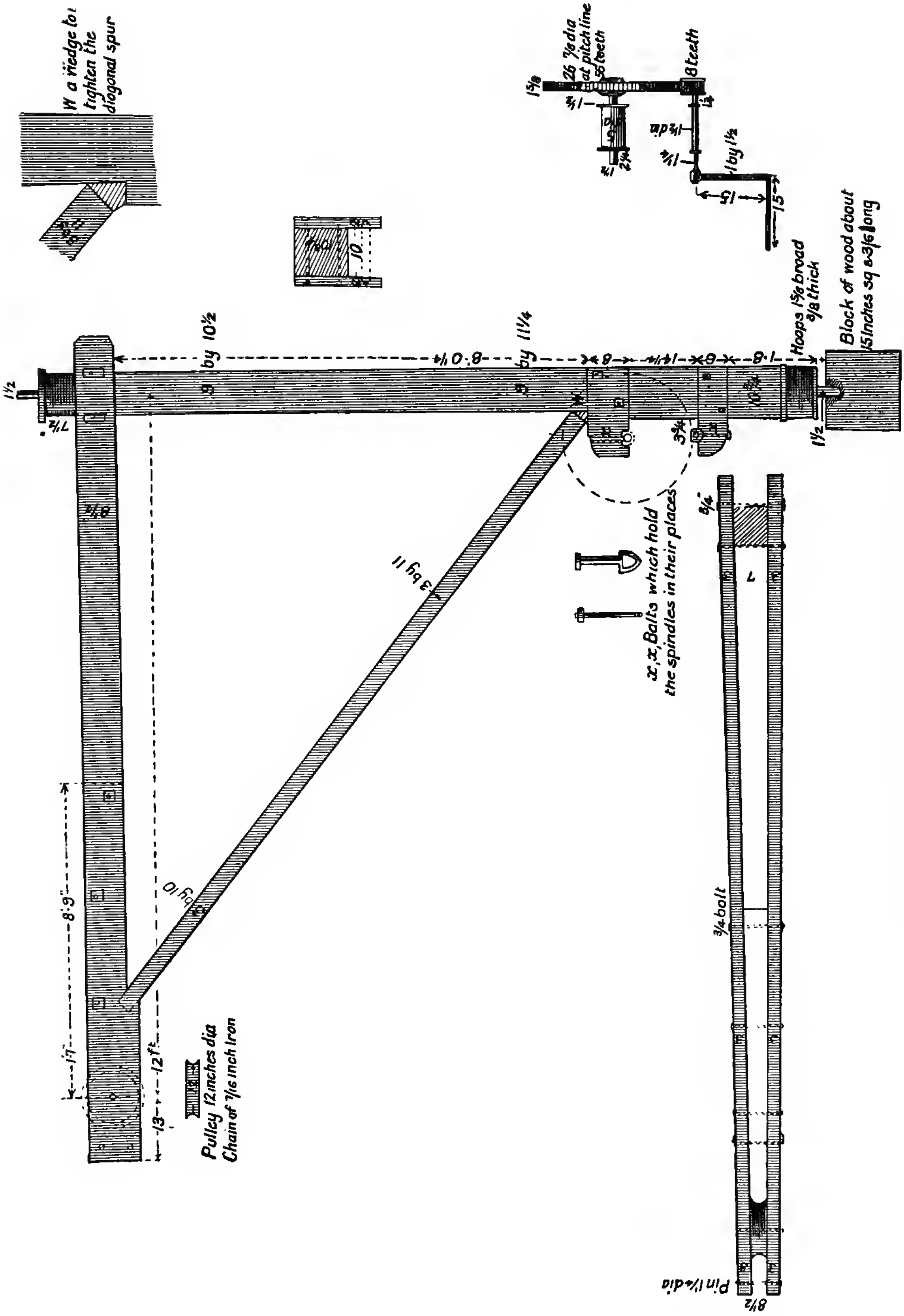
[1] See Appendix.

"The quantity of light is necessarily liable to some variation, from the difficulty of adjusting all the flames so as to be perfectly equal at all times; but the admirable precision and exactness with which the business of the Mill is conducted, afforded as excellent an opportunity of making the comparative trials I had in view, as is perhaps likely to be ever obtained in general practice. And the experiments being made on so large a scale, and for a considerable period of time, may, I think, be assumed as a sufficiently accurate standard for determining the advantages to be expected from the use of the gas lights under favourable circumstances.



VERTICAL RETORT FOR MESSRS. PHILLIPS & LEE'S GAS WORKS.
From the Original Drawing, dated November 1, 1805.

"It is not my intention, in the present Paper, to enter into a particular description of the apparatus employed for producing the gas; but I may observe generally, that the coal is distilled in large iron retorts, which during the winter season are kept constantly at work, except during the intervals of charging; and that the gas, as it rises from them, is conveyed by iron pipes into large reservoirs, or gazometers, where it is washed and purified, previous


W a wedge to tighten the diagonal spur
26 7/8 dia at pitch line 96 teeth
8 teeth
1⅝
1 by 1½
15
Hoops 1⅝ broad 3/8 thick
Block of wood about 15 inches sq & 3/6 long
by 10½
8·0¼
by 11¼
10¾
1½
x, x, Bolts which hold the spindles in their places
3 by 11
3 by 10
8·9"
1·7
12 ft
13
Pulley 12 inches dia
Chain of 7/16 inch Iron
3/4 bolt
Pin 1¼ dia
8½

RETORT CRANE FOR MESSRS. PHILLIPS & LEE'S GAS WORKS.
From the Original Drawing.

to its being conveyed through the pipes, called mains, to the Mill. These mains branch off into a variety of ramifications (forming a total length of several miles), and diminish in size, as the quantity of gas required to be passed through them becomes less. The burners, where the gas is consumed, are connected with the above mains, by short tubes, each of which is furnished with a cock to regulate the admission of the gas to each burner, and to shut it totally off when requisite. This latter operation may likewise be instantaneously performed, throughout the whole of the burners in each room, by turning a cock, with which each main is provided, near its entrance into the room.

" The burners are of two kinds: the one is upon the principle of the Argand lamp, and resembles it in appearance; the other is a small, curved tube with a conical end, having three circular apertures or perforations, of about a thirtieth of an inch in diameter, one at the point of the cone, and two lateral ones, through which the gas issues, forming three divergent jets of flame, somewhat like a fleur-de-lis. The shape and general appearance of this tube, has procured it among the workmen the name of the cockspur burner.

" The number of burners employed in all the buildings amounts to 271 Argands and 633 cockspurs; each of the former giving a light equal to two and a quarter of the same candles; making therefore the total of the gas light a little more than equal to that of 2500 candles. When thus regulated, the whole of the above burners require an hourly supply of 1250 cubic feet of the gas produced from cannel coal; the superior quality and quantity of the gas produced from that material having given it a decided preference in this situation, over every other coal, notwithstanding its higher price.

" The time during which the gas light is used may, upon an average of a whole year, be stated at least two hours per day of twenty-four hours. In some mills, where there is over work, it will be three hours; and in the few where night-work is still continued, nearly twelve hours. But taking two hours per day as the common average throughout the year, the consumption in Messrs. Phillips & Lee's Mill will be 1250 × 2 = 2500 cubic feet of gas per day; to produce which, seven hundredweight of cannel coal is required in the retort. The price of the best Wigan cannel (the sort used) is 13½d. per cwt. (22s. 6d. per ton), delivered at the mill, or say about eight shillings for the seven hundredweight. Multiplying by the number of working days in the year (313), the annual consumption of cannel coal will be 110 tons, and its cost £125.

" About one-third of the above quantity, or say forty tons of good common coal, value ten shillings per ton, is required for fuel to heat the retorts; the annual amount of which is £20.

" The 110 tons of cannel coal when distilled, produces about 70 tons of good coak, which is sold upon the spot at 1s. 4d. per cwt., and will therefore amount annually to the sum of £93.

"The quantity of tar produced from each ton of cannel coal is from eleven to twelve ale gallons, making a total annual produce of about 1250 ale gallons, which not having been yet sold, I cannot determine its value; but whenever it comes to be manufactured in large quantities, it cannot be such as materially to influence the economical statement, unless indeed new applications of it should be discovered.

"The quantity of aqueous fluid which came over in the course of the observations which I am now giving an account of, was not exactly ascertained, from some springs having got into the reservoir; and as it has not been yet applied to any useful purpose, I may omit further notice of it in this statement.

"The interest of the capital expended in the necessary apparatus and buildings, together with what is considered as an ample allowance for wear and tear, is stated by Mr. Lee at about £550 per annum; in which some allowance is made for this apparatus being made upon a scale adequate to the supply of a still greater quantity of light than he has occasion to make use of.

"He is of opinion, that the cost of attendance upon candles would be as much if not more than upon the gas apparatus; so that in forming the comparison nothing need be stated upon that score on either side.

"The economical statement for one year then stands thus:

Cost of 110 tons of cannel coal . . .	£125
Do. of 40 tons of common coal .	20
	£145
Deduct the value of 70 tons of coak . . .	93
The annual expenditure in coal, after deducting the value of the coak, and without allowing anything for the tar, is therefore	£52
And the interest of capital, and wear and tear of apparatus	£550
Making the total expense of the gas apparatus about £600 per annum.	
That of candles, to give the same light, would be about .	£2000

For each candle consuming at the rate of 4-10ths of an ounce of tallow per hour, the 2500 candles burning upon an average of the year two hours per day, would, at one shilling per pound, the present price, amount to nearly the sum of money above mentioned.

"If the comparison were made upon an average of three hours per day, the advantage would be still more in favour of the gas light; the interest of the capital, and wear and tear of the apparatus continuing nearly the same as in the former case; thus:

1250 × 3 = 3750 cubic feet of gas per day, which would be produced by 10¾ cwt. of cannel coals; this multiplied by the

number of working days, gives 168 tons per annum, which, valued as before, amounts to	£188
And 60 tons common coal for burning under the retorts will amount to	30
	£218
Deduct 105 tons of coak at 26s. 8d.	140
Leaving the expenditure in coal, after deduction of the coak, and without allowance for the tar, at	£78
Adding to which the interest and wear and tear of the apparatus as before, the total annual cost will not be more than	£650
Whilst that of tallow, rated as before, will be	£3000

"It will readily occur, that the greater number of hours the gas is burnt, the greater will be its comparative economy ; although in extending it beyond three hours, an increase of some parts of the apparatus would be necessary.

"If the economical comparison were made with oils, the advantages would be less than with tallow.

"The introduction of this species of light into the establishment of Messrs. Phillips & Lee, has been gradual ; beginning in the year 1805, with two rooms of the mill, the counting-houses, and Mr. Lee's dwelling-house. After which, it was extended through the whole of the manufactory, as expeditiously as the apparatus could be prepared.

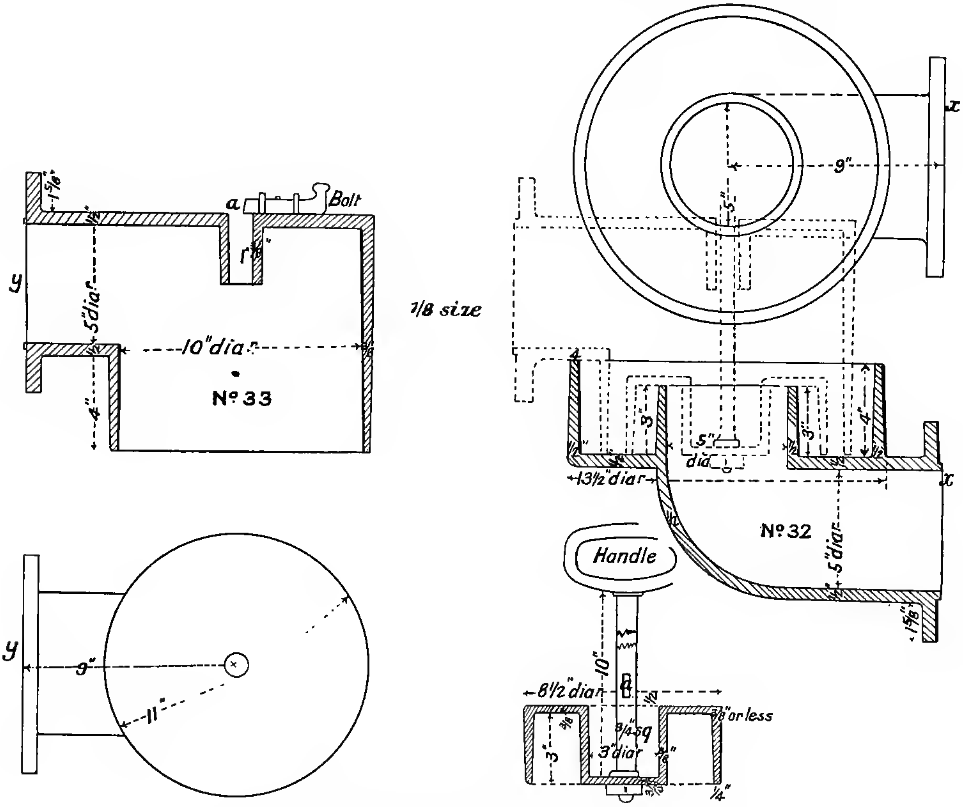
"At first some inconvenience was experienced from the smell of the unconsumed or imperfectly purified gas, which may, in a great measure, be attributed to the introduction of successive improvements in the construction of the apparatus, as the work proceeded. But since its completion, and since the persons to whose care it is confided have become familiar with its management, this inconvenience has been obviated, not only in the mill, but also in Mr. Lee's house, which is now brilliantly illuminated with it, to the exclusion of every other species of artificial light.

"The peculiar softness and clearness of this light, with its almost unvarying intensity, have brought it into great favour with the work people. And its being free from the inconvenience and danger resulting from the sparks and frequent snuffing of candles, is a circumstance of material importance, as tending to diminish the hazard of fire, to which cotton mills are known to be much exposed.

"The above particulars, it is conceived, contain such information as may tend to illustrate the general advantages attending the use of the gas light ; but nevertheless the Royal Society may perhaps not deem it uninteresting to be apprised of the circumstances which originally gave rise in my mind to its application, as an economical substitute for oils and tallow.

"It is now nearly sixteen years since, in a course of experiments I was making at Redruth, in Cornwall, upon the quantities and qualities of the gases produced by distillation from different mineral and vegetable substances, I was induced by some observations I had previously made upon the burning of coal, to try the combustible property of the gases produced from it, as well as from peat, wood, and other inflammable substances. And being struck with the great quantities of gas which they afforded, as well as with the brilliancy of the light and the facility of its production, I instituted several experiments with a view of ascertaining the cost at which it might be obtained, compared with that of equal quantities of light yielded by oils and tallow.

"My apparatus consisted of an iron retort, with tinned copper and iron tubes through which the gas was conducted to a considerable distance, and there, as well as at intermediate points, was burned through apertures of varied forms and dimensions. The experiments were made upon coal of different qualities, which I procured from distant parts of the Kingdom, for the purpose of ascertaining which would give the most economical results. The gas was also washed with water, and other means were employed to purify it.



GAS TRAP FOR MESSRS. PHILLIPS & LEE'S GAS WORKS.

From the Original Drawing, dated October 30, 1805.

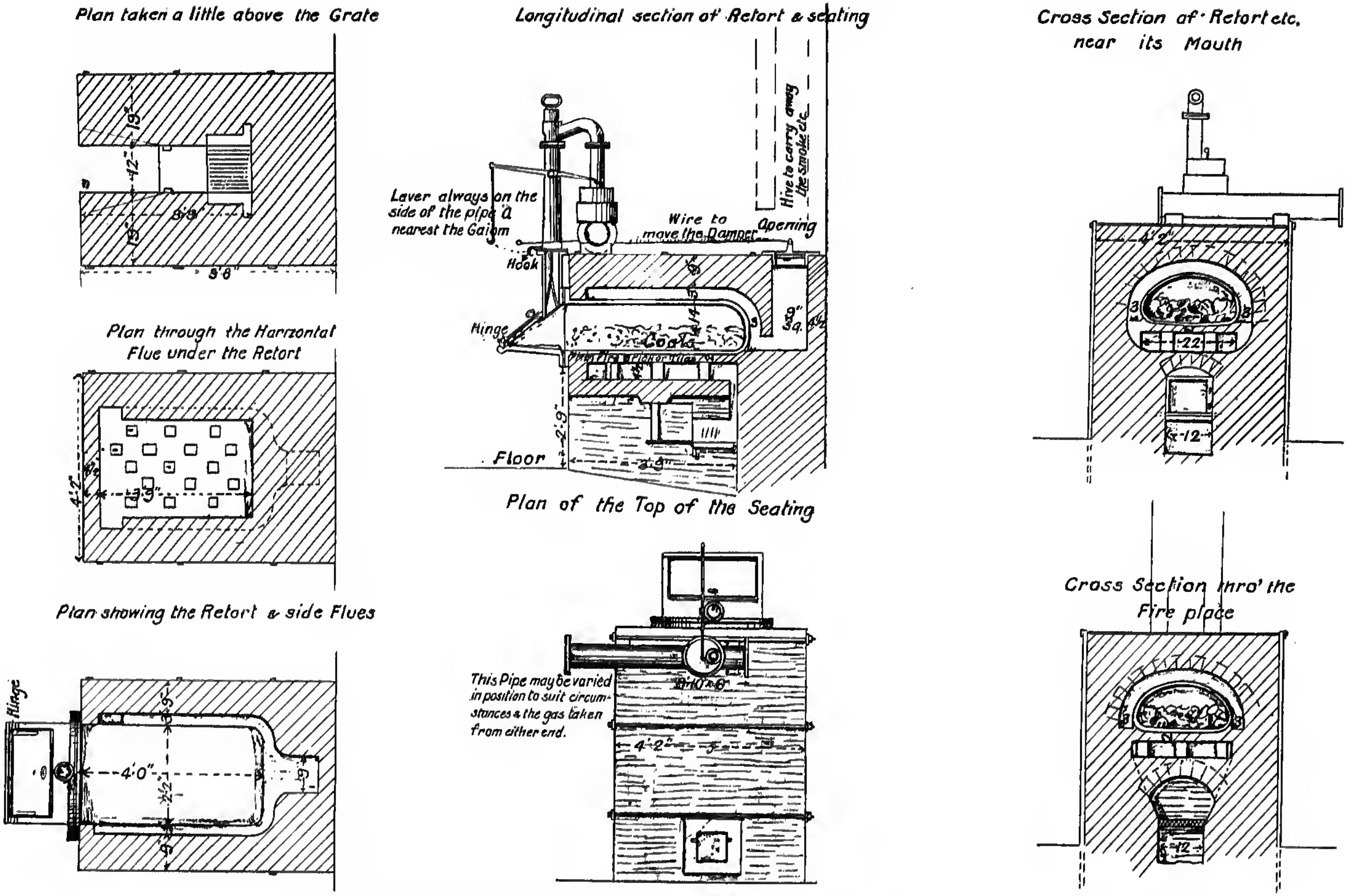
"In the year 1798, I removed from Cornwall to Messrs. Boulton, Watt, & Co.'s works for the manufactory of steam engines at the Soho Foundry, and there I constructed an apparatus upon a larger scale, which during many successive nights was applied to the lighting of their principal building, and various new methods were practised, of washing and purifying the gas.

"These experiments were continued with some interruptions, until the peace of 1802, when a public display of this light was made by me in the illumination of Mr. Boulton's manufactory at Soho, upon that occasion.

"Since that period, I have, under the sanction of Messrs. Boulton, Watt, & Co., extended the apparatus at Soho Foundry, so as to give light to all the principal shops, where it is in regular use, to the exclusion of other artificial light; but I have preferred giving the results from Messrs. Phillips & Lee's apparatus, both on account of its greater extent, and the greater uniformity of the lights, which rendered the comparison with candles less difficult.

"At the time I commenced my experiments, I was certainly unacquainted with the circumstance of the gas from coal having been observed by others to be capable of combustion; but I am since informed that the current of gas escaping from Lord Dundonald's tar ovens had been frequently fired; and I find that Dr. Clayton in a Paper in Volume 41 of the *Transactions of the Royal Society*, so long ago as the year 1739, gave an account of some observations and experiments made by him, which clearly manifest his knowledge of the inflammable property of the gas, which he denominates 'the spirit of coals;' but the idea of applying it as an economical substitute for oils and tallow does not appear to have occurred to this gentleman, and I believe I may, without presuming too much, claim both the first idea of applying, and the first actual application of this gas to economical purposes."

Following upon the publication of this account, there appeared in Nicholson's *Journal* (vol. xxi., p. 291) a letter, dated 22nd November, 1808, from Benjamin Cook, describing an apparatus employed by him for the production of coal gas, and the advantages of its use in small manufactories. This apparatus is stated by Matthews to have been constructed for Cook by Pemberton, but no mention is made of this circumstance in the letter. The writer lays stress upon the economy of this means of producing artificial light, "especially now, through the present rupture with Russia, and the other northern powers, the want of importation of tallow has increased to a very considerable height the price of candles, soap, &c. The rise in price of candles has of course been the occasion of an equal rise in oil, as lamps are substituted in the place of candles." He advocates the use of coke as lasting much longer than coal in an ordinary fire; two fires of coke, he says, will last longer than three made of coal. He is also of opinion that from the tar "a spirit might be made, as a substitute for the tar spirit brought from Russia, &c.;" this having advanced from 3s. or 3s. 6d. to 20s. per gallon since the stoppage of trade from the North. We thus get a glimpse at the effects produced upon trade in this country by the famous Berlin decrees of Napoleon. There were in Birmingham at that time, and, indeed for many years afterwards, a great number of very small manufacturers, men who worked at the bench them-


Plan taken a little above the Grate
19"
12"
19"
3'8"
3'8"
Plan through the Horizontal Flue under the Retort
4'2"
3'3"
Plan showing the Retort & side Flues
Hinge
4'0"
2'2"
6"
6"
Longitudinal section of Retort & seating
Laver always on the side of the pipe a nearest the Gaiom
Hook
Hinge
Wire to move the Damper
Opening
Hive to carry away the smoke etc.
9" Sq.
14
Coals
Floor
2'9"
3'9"
Plan of the Top of the Seating
This Pipe may be varied in position to suit circumstances & the gas taken from either end.
4'2"
Cross Section of Retort etc. near its Mouth
4'2"
22
12
Cross Section thro' the Fire place
12

HORIZONTAL RETORT FOR MESSRS. PHILLIPS & LEE'S GAS WORKS.

From the Original Drawing, dated May 17, 1808.

selves, and employed at most but a few hands. It is to these Mr. Cook refers when he says that " Mr. Murdock's paper is on the great scale, therefore far above the circulation of the simple mechanic ; and it is to the great number of these that the thing ought to be made clear. To them a small saving of ten pounds per annum is of as great consequence as to the wealthy their thousands." He describes his apparatus as consisting simply of a " small cast-iron pot of about eight gallons, with a cast-iron cover, which I lute to it with sand. Into this pot I put my coal. I pass the gas through water into the gasometer, or reservoir, which holds about 400 gallons ; and by means of old gun barrels convey it all round my shops. Now from 20 or 25 lbs. of coal I make perhaps 600 gallons of gas ; for when my reservoir is full we are forced to burn away the overplus in waste, unless we have work to use it as it is made. But in general we go on making and using it, so that I cannot tell to 50 or 100 gallons ; and in fact a great deal depends on the coal, some coals making much more than others. These 25 lbs. of coal put into the retort, and say 25 lbs. more to heat the retort, which is more than it does take one time with another, but I am willing to say the utmost, are worth four pence per day. From this four pence we burn 18 or 20 lights during the winter season. The candles we used were 6 to the pound, which on an average one time with another would be about 2d. each though not nearly 2½d. Say 18 candles at 2d. each are 3s. a day or 18s. a week ; and that each man burnt his candle for 20 weeks only in the year, though for the winter quarter he in general has burnt 2 instead of 1 ; making the annual amount £18.

" Besides, my yearly expense in oil and cotton for soldering was full £30, which is entirely saved, as I now do all my soldering by the gas flame only. My trade is that of a manufacturer of toys, in metal and gold. Now, in all button soldering, all the plated articles, in fact all trades in which the blowpipe is used with oil and cotton, the gas flame will be found more superior, both as to quickness and neatness in the work ; for the flame is sharper, and is constantly ready for use, while with oil and cotton the workman is always forced to wait for his lamp getting up ; that is, until it is sufficiently on fire to do his work. Thus a great quantity of oil is always burnt away useless ; but with the gas, the moment the stop-cock is turned, the lamp is ready, and not a moment is lost.

" You see my weekly expenditure in coal does not exceed 2s. ; and if I allow 5s. a week to a man, to employ part of his time to attend to make the gas, the expense will then be 7s. The yearly expense, if I take it at the same the whole year (although for 25 or 30 weeks in the year none will be required as candles) will amount to £18, 4s. I have, I know, in the instance of candles, much underrated the expense, as also in oil. I have also estimated the expense in coal, &c., quite high enough ; and the coke I find equally as cheap to burn in my small stoves in the shops as coal ; so that I do not overrate this, when I say £2, 10s. for it. The expense of putting up my apparatus was about £50 ; but not knowing the cheapest and readiest methods to go about it, it cost me more than it ought by £15. I will say £40, for which in my statement at the conclusion I shall allow interest.

" If erected on a smaller scale, the saving to the manufacturer is equally as great; for the poor man who lights only 6 candles, or uses one lamp, if the apparatus is put up in the cheapest way, will find it only cost him £10 or £12, which he will nearly if not quite save the first year. And if the pipes are made of old gun barrels, as mine are, and once a year, or once in two years, are coated over with tar to keep them from rusting, they will last half a century. The burst or waste barrels, that used to be sold for old iron, would then produce a better price to the gunmakers; and the pipes would be better and more durable than if made of more slight materials.

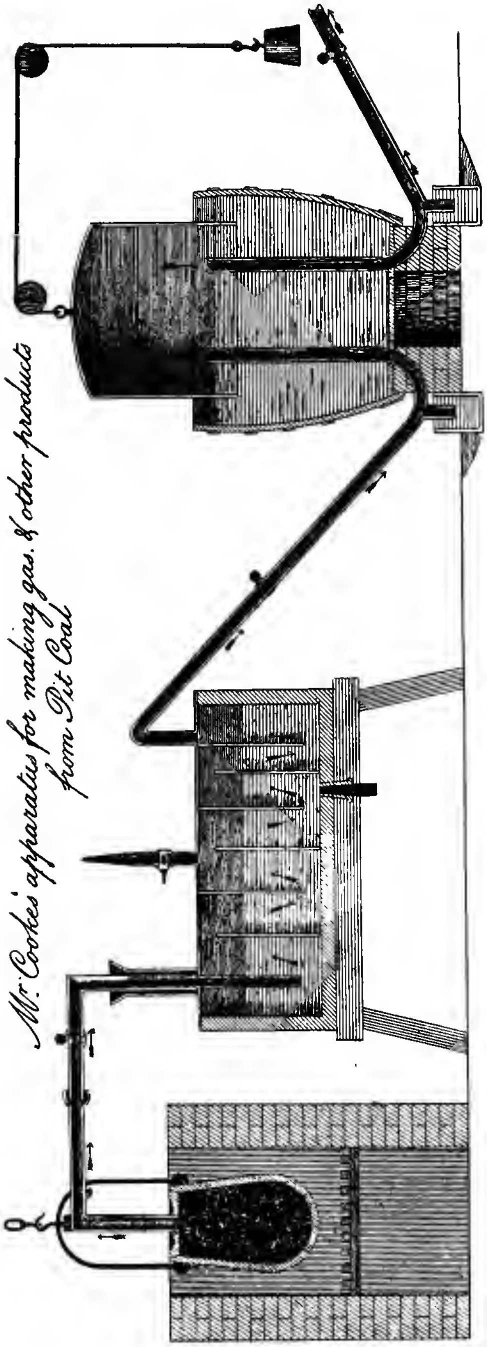
Dr.				*Cr.*			
Yearly expense in coals and man . .	£18	4	0	Twenty weeks at eighteen shillings per week for candles . .	£18	0	0
Interest on forty pounds .	2	0	0	Oil and cotton for lamps	30	0	0
Profits per year . .	30	6	0	Cokes worth . .	2	10	0
	£50	10	0		£50	10	0"

In a subsequent letter to Nicholson's *Journal* (vol. xxii., p. 145), dated 27th December, 1808, Cook modifies his opinion as to the utility of old gun barrels for conveying the gas, as he found they required many joints, or "soldering places." On that account he expresses preference for "patent lead pipe," to be had in lengths of 15 to 20 feet, and ¾ inch or 1 inch in diameter. The following corrected statement of saving to be effected by the use of gas is also given:

Dr.				*Cr.*			
Coal for 20 weeks at 1s. 3d.	£1	5	0	Twenty weeks at 18s.	£18	0	0
Interest on £20 or £25 .	1	5	0	Coke	0	12	6
Saved . . .	16	2	6				
	£18	12	6		£18	12	6

Cook's experience of the unsuitability of old gun barrels for internal gas fittings did not prevent their subsequent very general use for service pipes, for which purpose they were screwed together. The present author, it may be mentioned, when engaged about thirty years ago in making some alterations to the distributing mains in New Street, Birmingham, came across an old gun barrel which formed a part of an unused gas service.

In 1810, Cook communicated to the Society of Arts a description of the apparatus used by him for the production of illuminating gas, in which he refers to the practicability of making varnish and naphtha from the coal-tar obtained. This description is accompanied by an illustration of the apparatus,



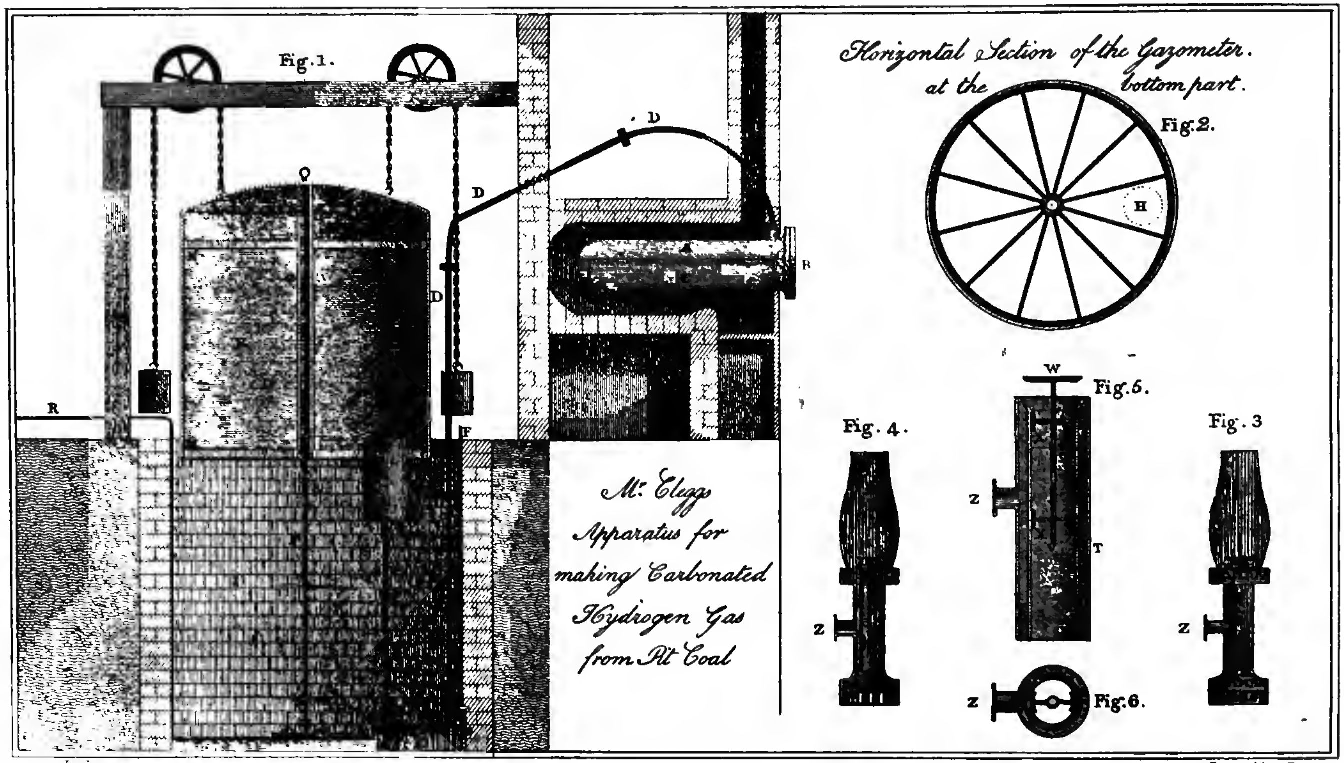
Mr Cooke's apparatus for making gas & other products from Pit Coal

which is here reproduced. For this communication Cook was awarded the large silver medal of the Society.

Reference has already been made in this chapter to the work of Samuel Clegg in connection with the introduction of gas lighting. In the same year—namely, 1808—in which Murdoch communicated his invention to the Royal Society and was awarded for it the Rumford gold medal, Clegg sent to the Society of Arts an account of his apparatus "for making Carbonated Hydrogen Gas from Pit Coal, and Lighting Factories therewith." This account, for which Clegg received the Society's silver medal, is as follows:—

Dear Sir,—When your son was in Manchester, he called to see my nephew's, Samuel Clegg's, improved gas lights, and was desirous to have a plan of his method, which my nephew promised to him, and I undertook to get it conveyed to you. I have, accordingly, taken the opportunity of sending to the Society of Arts, &c., a plan and explanation of his apparatus.

He lighted a large factory in Yorkshire some years ago upon this principle, and has since lighted some buildings in this neighbourhood, and I believe he is the first person who succeeded in rendering these lights free from the offensive smell which generally accompanies them. My nephew served an apprenticeship to Messrs. Boulton & Watt, of Birmingham, in the steam-engine business, MECHANICS.



Mr. Clegg's Apparatus for making Carbonated Hydrogen Gas from Pit Coal

Horizontal Section of the Gazometer. at the bottom part.

Engraved by S. Porter

in which he is now engaged here on his own account, and has made considerable improvements in their construction.

I remain, dear Sir,

Your most obedient servant,

ASHWORTH CLEGG.

Manchester, 18th May, 1808.

To C. Taylor, M.D., Sec.

SIR,—Your esteemed favour I have received, and, according to your request, have sent you a fuller explanation of the gazometer and lamp, accompanied with further drawings.

A gazometer, containing seven hundred cubical feet of gas, weighs about twenty hundredweight, and costs about two pounds ten shillings the hundredweight.

The whole of an apparatus complete, capable of supporting forty lamps, for four hours, each lamp affording light equal to ten candles of eight in the pound, will cost about two hundred and fifty pounds. Each lamp consumes six cubical feet of gas per hour. I am happy to find that the Society have honoured my communications with their attention, and I remain, with great respect,

Sir,

Your most obedient servant,

S. CLEGG.

Manchester, 12th August, 1808.

To C. Taylor, M.D., Sec.

Reference to Mr. S. Clegg's improved Apparatus for extracting Carbonated Hydrogen Gas from Pit Coal. (See illustration, p. 85, Figs. 1, 2, 3, 4, 5, and 6.)

"In Fig. 1, A shows the cast-iron retort, into which are put the coals intended to be decomposed by means of a fire underneath it, the heat of which surrounds every part of it, excepting the mouth or part by which the coals are introduced. The lid or iron plate B, which covers the mouth of the retort, is ground on air-tight, and fastened by means of a screw in the centre. C is a shield or saddle of cast iron, to preserve the retort from being injured by the intensity of the fire underneath it, and to cause it to be heated more uniformly. D D D represents the cast-iron pipe which conveys all the volatile products of the coal to the refrigeratory of cast-iron E, in which the tar, &c., extracted from the coal is deposited, and from whence they can be pumped out by means of a copper pipe F. G is the pipe which conveys the gas to the cylindrical vessel or receiver H; this receiver is air-tight at the top, and consequently the gas displaces the water in the vessel H, to a level with the small holes, where the gas is suffered to escape and rise through the water of the well I, into the large gazometer K. The use of the vessel H is pointed out as follows, viz.: If the pipe G reached all through the water, without passing through the vessel H, the gas would not be rendered pure or washed; and if part of the pipe did not rise above the water, the water would have free communication with the tar, besides exposing the retort A to a very great pressure, so as to endanger its bursting when red hot. This vessel or receiver H, in a large apparatus, is about eighteen inches diameter and two feet long; the quantity of gas, therefore, which it contains, is sufficient to fill the pipes and retort when cold, and prevents the pipe G from acting as a syphon, and exposes the gas to the water without endangering the retort.

"When the operation begins, the upper part of the cylindrical gazometer K, Fig. 1, made of wrought plates, is sunk down nearly to a level with the top of the circular well I, and is consequently nearly filled with water, but it rises gradually as the gas enters it and displaces the water; the two lengths L L suspended over pullies by chains keep it steady and prevent its turning round, otherwise the lower stays M of the gazometer would come into contact with the vessel H. There are two sets of these stays, one shown at M, and the other at N.

"There is also an iron pipe O made fast in the centre of the gazometer, by means of the stays, which slides over the upright pipe P, by which contrivance the gazometer is kept firm and steady, when out of the well; it likewise prevents the gas from getting into the cast-iron pipe P, and the copper pipe R, anywhere but through small holes made in the pipe O at S at the top of the gazometer, where the gas is perfectly transparent and fit for use.

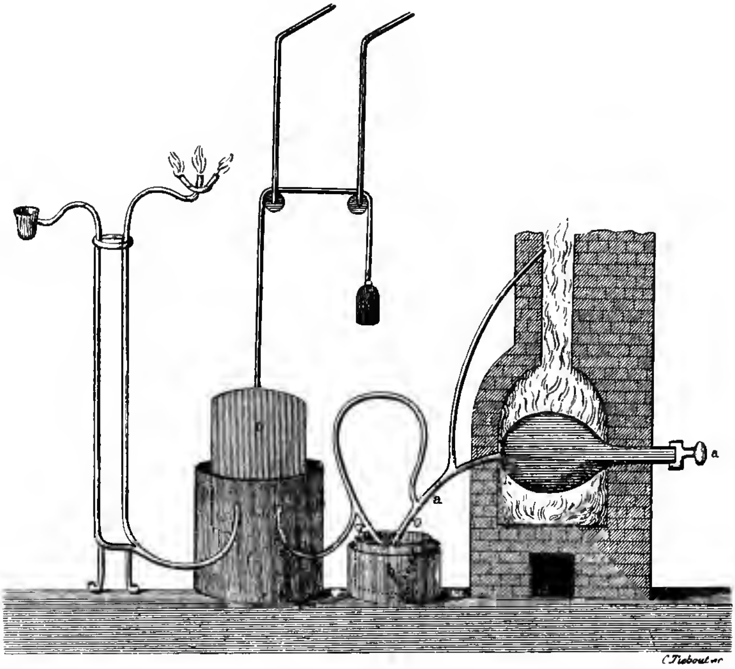
"The pure gas enters the tube O at the small holes made in its top at S, and passes on through the tubes P and R to the lamps, where it is consumed and burnt.

"The seams of the gazometer are luted to make them air-tight, and the whole well painted inside and out, to preserve it from rust.

"Fig. 2 shows a horizontal section of the lower hoop of the gazometer K at the part M, with its stays or arms, and the manner in which the iron pipe C, before described as Fig. 1, sliding on the tube P, passes through the ring in the centre of the hoop; a horizontal section of the receiver H appears therein.

"Fig. 5 shows a section of one of the gas lamps; the space between the outer tube T and the inner tube V is to be filled with gas supplied by the pipe R, shown in Fig. 1, where a stop-cock is inserted for adjusting the flame, which gas passes through a number of small holes made in the outer edge of the circular plate shown at Fig. 6, which unites the tubes T and V at their tops. V is the inner tube which conveys the atmospheric air into the centre of the flame; the upper part of this tube is made conical, or widening outwards, to join a circular plate with holes in it, a horizontal view of which is shown at Fig. 6. W is a button, which can be placed at a small distance above the mouth of the lamp, and its use is to convey, in an expanded manner, all the air which rises through this tube to the inner surface of the flame, which assists the combustion very much; this button may be set at any convenient distance above the tubes of the lamp, as it slides in the cross bars X X, by which it is supported in the inner tube.

"A current of air also passes between the glass tube or chimney and the outer tube T, through holes made in the bottom of the glass-holder, as in Argand's lamp; this surrounds the flame, and completes its combustion, as explained by the view Fig. 3, and section, Fig. 4, which have a glass upon each. Z Z Z Z, Figs. 3, 4, 5, and 6, show the tube through which the lamp is supplied with gas from the pipe R, Fig. 1."[1]



COAL GAS APPARATUS.

As illustrated in Parkes' "Chemical Catechism."

Mention has already been made (Chapter I. p. 19) of a brief reference to gas lighting which appeared in the 1808 edition of Nicholson's *Dictionary of Chemistry*. A more extended reference was made in the same year by Parkes in his *Chemical Catechism* (3rd edition, 1808), which has for frontispiece the illustration given above. This (p. 17) is as follows: "Where great quantities of candles are used, as in large manufactories, mines, collieries, &c., a great saving would arise from the use of carburetted hydrogen gas, which produces a beautiful intense light, much more cleanly than oil or tallow, and at little or no expense. A slight knowledge of the mode of managing the gases would enable the proprietor of collieries to procure this gas from the small coal which is *trodden under foot*, and to light up his coal-pits with it with the greatest safety and at no expense. If this mode were adopted, the workmen would be lighted much better than they can possibly be by any other means; thousands of pounds would be annually saved to the community; and the many tons of tallow, which are now consuming in these subterranean works, might be used in the manufacture of soap; which would tend to lower the price of that necessary article, and render our poor much more wholesome and comfortable." Further on (p. 311) it is stated that "carburetted hydrogen is procured from pit-coal by dry distillation for the purpose of forming the thermo-lamp, and is now proposed to be employed for lighting the public streets, lighthouses on the sea-coasts, mines, manufactories, &c."

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[1] *Journal of the Society of Arts*, vol. xxvi. (1808), pp. 202–6.

The account given by Murdoch to the Royal Society shows that the gas made for the supply to Phillips & Lee's factory travelled through "several miles of pipes." Moreover, in the communication of L. L. to the *Mechanics Magazine*, which has been already referred to, it is stated that "in the latter end of 1806, by order of the borough-reeve of Manchester, Clegg lighted one of the lamps in King Street, to see how far gas was applicable for street lights. For this purpose he filled a gasometer sufficiently capacious from his own apparatus in Dean's Gate, and then inserted it in a tank of water. The light was much admired by the whole town. Mr. Clegg made an offer to illuminate the whole street, and fix an apparatus for that purpose, for £140; but, strange to say, the offer was not accepted." It does not, however, appear that either Murdoch or Clegg, or any other of the makers of gas apparatus who have been mentioned, contemplated at that early time any scheme for the distribution of gas from a central source. This was, perhaps, felt to be impracticable, not from any apprehension of physical difficulty, but mainly on the ground of expense; cast-iron pipes, for example, being very high in price at that time. However this may have been, it was reserved for Frederick Albert Winsor, a man of but little practical experience, but possessed of an extremely sanguine temperament and unbounded imagination, to be the first to publicly advocate such distribution.

CHAPTER IV.

WINSOR.

WINZER, or WINSOR, as he preferred to be called on settling in this country, was a native of Zuaïm, in Moravia. He left Paris, as he himself tells us, in April, 1802, disappointed at not having been able to procure from Lebon one of his Thermolamps, but evidently in possession of sufficient information to enable him to pursue the subject. Of this period he writes that, "being in my travels, I could only study during the day, and labour during the *nights*, in the trial of numerous experiments and divers utensils, many of which were spoiled, and the best but indifferently made by the workmen abroad." He considered himself, however, to be "a legitimate and successful imitator and proprietor" of Lebon's process, in which character he first appeared in Brunswick, where he arrived in the autumn of 1802. Here "his Serene Highness the reigning Duke, and all his Ministers, and hundreds of the learned and curious, honoured me by their visits." Here, also, he published, as mentioned in Chapter II., Lebon's description of his apparatus in three languages, with a supplement dedicated to the Duke of Brunswick. Apparently not meeting with much success from the patronage of this "Protector, Judge, and Lover of Arts and Sciences," he proceeded to England. "The thought," he says in 1807, "of introducing the discovery for the great advantage of the British realm struck me, five years ago, like an electric spark, which has ever been kept alive in my mind, and added, from day to day, from week to week, fresh fuel to my hope of *rendering it generally beneficial*." On arriving in England, he, according to Matthews, made the acquaintance of a Mr. Kenzie, a retired coachbuilder, who resided in Green Street, Grosvenor Square.[1] Some unoccupied premises belonging to this gentleman having been placed at his disposal, Winsor continued there his experiments for producing gas from coal—wood having been used by Lebon; and in 1803 and 1804, he publicly exhibited his gas lights at the Lyceum Theatre in London. Here he showed, by a variety of experiments, how gas could be conveyed from place to place, and also how, by using different kinds of burners, a variety of forms could be given to its flame. The advantages

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[1] Winsor himself was residing at No. 41, Green Street, Grosvenor Square, in 1807, as appears from his advertisement.

FREDERICK ALBERT WINSOR.

From the Portrait in possession of the Gas Light & Coke Company.

of "a light without a wick" were ingeniously displayed; and the exhibition proved to be attractive to the public, the visitors to it being very numerous. It was not, however, unattended with some vexations. Lectures accompanied the experiments, with regard to which Winsor says that "never having been used to any public business of this nature, but to mercantile transactions only, I resolved to instruct some person to read my public lectures, and make my experiments." The person so engaged, after having been nearly six weeks in Winsor's service, failed, one lecture night, to appear at the appointed time, "when," says Winsor, "the large theatre happened to be quite crowded. I was thrown into the most unpleasant situation; for he had my manuscript lecture in his pocket; of course I was under the necessity of sending home a number of disappointed persons, after making them wait an hour and a half." It was but little satisfaction to him to learn from the defaulting assistant, when he did eventually appear, that "he had been dining with friends." It can do no harm now to say that the individual who thus disappointed a London audience was no other than Edward Heard, who was subsequently the first to take out a patent for the use of lime for purifying gas, by which, as already mentioned, he anticipated Cooper's liming process.

Winsor says of this patent that he used lime years before, in various shapes, as a means of purifying gas. The previous use of lime is not at all improbable, since its suitability for the purpose seems to have been generally recognized. Heard, however, in 1806 (No. 2941) patented a particular method of using it, namely, its stratification "with the coals in the retort, stove, or other close vessel in which they are placed for operation," and is consequently entitled to whatever merit may attach to the true and original inventor of such method.

Winsor, moreover, himself took out a patent in 1804 (No. 2764), in which there is no mention of the use of lime. It is the first which stands in his name in connection with the production of gas from "fuel."

This is for "An improved Oven, Stove, or Apparatus, for the purpose of extracting inflammable Air, Oil, Pitch, Tar, and Acids from, and reducing into Coke and Charcoal all kinds of Fuel, which is also applicable to various other useful Purposes." The specification proceeds to describe "a metal, brick, or earthen stove, oven, retort, or vessel so constructed to reduce by means of fire and heat all raw fuel of any kind into coke and charcoal without any or little consumption of the fuel, by which operation the smoke being extracted from all raw fuel, is then conducted through cold air or water into a condensator, where, after being sufficiently cooled and purified, it undergoes a natural chemical resolution into tar, pitch, oil, acid, ammonia, inflammable gas or air. Thus, by the above means of carbonizing raw fuel with heat instead of burning it, the whole weight is preserved, and resolved into said products. Any metal, brick, or earthen stove, oven, retort, or vessel constructed as above may dry, melt, heat, distil, or boil away any copper pan, pot or vessel in refineries, breweries, distilleries, smelteries, forges, steam engine, or any other purpose whatever where much fuel is consumed, which, to save and preserve the above principle of carbonization, can be applied, first to heat any vessel, &c., by the construction of such a carbonizing utensil; secondly, to heat another vessel, &c., by the hot smoke extracted from raw fuel; thirdly, to heat a third vessel, &c., by the inflammable air or gas made from smoke; and fourthly, to heat any fourth vessel, &c., with the coke or charcoal saved by this principle of carbonization." After enumerating some of the uses to which the residuals may be applied, it is mentioned that "the inflammable gas or air being purified from that carbon so pernicious to respiration and dwellings, may be led and conducted in a cold state through tubes of silk, paper, earth, wood, or metal, to any distance in houses, rooms, gardens, places, parks, and streets, to produce light and heat."

In the same year—namely, 1804—Winsor published two pamphlets. One of these is entitled

THE
SUPERIORITY
OF THE
NEW PATENT COKE,
OVER THE USE OF COALS,
IN ALL FAMILY CONCERNS,
DISPLAYED, EVERY EVENING,
AT THE LARGE THEATRE,
LYCEUM, STRAND.
ETC. ETC.

"Addressed to all the enlightened inhabitants of London and the British Empire," the object of it being, as its title implies, to set forth the advantages of the new coke over coals, and the inconveniences and dangers attending the use of the latter; amongst which, by the bye, no mention is made of fogs, although naturally the avoidance of smoke is made the most of. The pamphlet gives the price of coals for the period as under:

In 1799	from 44s. to 57s.	per chaldron.
„ 1800	„ 47s. to 58s. 6d.	„
„ 1801 to 1803	„ 47s to 63s.	„

The other and more ambitious pamphlet has for its title

ACCOUNT
OF THE
MOST INGENIOUS AND IMPORTANT
NATIONAL DISCOVERY FOR SOME AGES.
BRITISH IMPERIAL
PATENT LIGHT OVENS AND STOVES
by which above
1000 per cent. are saved and gained in Light, Heat, and some valuable products for British Manufactures, Commerce, and Navigation; as proved by an exact Account Current of *Profit* and Loss affixed.
RESPECTFULLY DEDICATED TO BOTH HOUSES OF PARLIAMENT
AND
ALL PATRIOTIC SOCIETIES;
AND RECOMMENDED TO
All the learned in Physics and Chemistry; But particularly to all Gentlemen interested in the English Fire Insurance Offices, for a considerable Reduction of the most dreadful Accidents in Human Life,
AND FOR
THE PROMOTION OF SO MANY NATIONAL ADVANTAGES.
BY
F. A. WINSOR,
The Second Inventor and Improver.

The introduction to this work is taken up with an account of Winsor's relations with Lebon, and his abortive efforts to procure from the latter one of his Thermolamps, which have already been referred to. In the description of the process it is stated that, "the daily increasing scarcity and dearth of fuel all over Europe has already excited the attention, as much as the apprehension, of several men of state and learning, who, judging with a wise foresight, from evils of the *past,* wish to provide against those of *future* ages; because forests, coal-mines, and turflands, though ever so numerous or extensive, *may be at last exhausted* by the consumption of centuries." After contemplating the exhaustion of English coal mines, the author goes on to say: "Since the beginning of the world, mankind have lost above 80 per cent. in all combustibles, by the *mere* evaporation of smoke. This very smoke, which often proves troublesome and dangerous to health and houses, is now discovered to contain the *most valuable* substances, and, if properly extracted, gathered, washed, purified, and resolved, regain no less than *five costly products*, viz. oil, pitch, acid, coke, and gaz, which latter product not only furnishes the most *intense heat*, and the *purest light* whenever it is wanted, but can also be applied to supersede the dangerous and expensive steam engine ; because a celebrated French engineer proves that the *azot* it produces by a mixture with the atmospheric air, is capable of tenfold powers if employed in the freezing point only."

The pamphlet proceeds to point out in unstinted language the astonishing advantages to be derived from the process of which one great product was the " pyroligneous and coal acidities," which in its crude state was claimed to be " one of the strongest *lies* for tanning skins, much cheaper, quicker, and superior than can possibly be done by bark, &c." . . . " It will also render hams, bacon, beef, &c., much sooner impenetrable to the corruption of air, than is done by the smoke of wood," while " in its refined state it is necessary to and very valuable in the fabrication of white lead, verdigrease, copperas, and alum." Moreover, " in dying black, it renders the hue much deeper, and fixes the colour much stronger, than alum, galls, or any other ingredient." As to this, the author relates a little personal experience which entitles him to sympathy, for he says, " I had several of my clothes tinged by this lie, which would never wash out again."

As to the application of the gas for lighting and heating, Winsor says that " in repairing of old houses, and building of new ones, such arrangements may be made as to have *every apartment lighted and heated from the kitchen*, or from the wash-house, whichever proves most convenient." Such arrangement, he estimates, would for a new building save three-fourths of the cost of chimney places, pieces, boards, stoves, fenders, tongs, pokers, &c. ; while " the repairing or arranging of every old house would be defrayed from the product of every kind of chimney furniture, which, if sold as old iron only, would sufficiently pay all manner of expense in fitting it up according to the new system." Equally sanguine is he as to the heating value of coal gas—for " one tasty crystal globe, on a marble pedestal, or otherwise, will also light, and sufficiently heat, the largest room during the winter." " *Tasty girandoles*," moreover, " arranged for the purpose, will lighten our tables, and warm our plates, at the same time, if necessary, without any artificial aids of spirits of wine, plate warmers, &c. ; " while " illuminated garlands, flowers, festoons, urns, vases, busts, and statues of every kind, will bring ornament, heat, and light, throughout our dwellings, which will satisfy the nicest taste, and charm every eye. . . . We may light and warm our streets, playhouses, lighthouses, and all public buildings, in a far superior style and much less expensive manner, than we can do with wax, tallow, or oils." . . .

" The lighthouses on our coasts may be rendered like blazing stars, to guide our seamen over the watery deep ; nay, the very signals of vessels and fleets by night, may be materially improved, and rendered more distinct than in the brightest days." . . .

" The most brilliant fireworks are the delight of some minutes at an *extra-*

vagant expense; but a light stove will yield a lasting fire and flame, in all manner and form that taste or fancy may direct, and at no expense, if the products gained are applied to useful purposes.

"Nay, it will almost appear incredible to assert, that the same table, desk, or sideboard, which furnishes a light or flame, will serve to warm my room, and even dress my victuals, in case of need; and by the mere turning of a cock, or the corking or uncorking of a small pipe or tube.

"As to illuminations, they may be carried on to the utmost extent of beauty, and variegated fancy, by this docile flame, which will ply in all forms, submit to instant changes, ascend in columns to the clouds, descend in showers from trees, walls, &c., arise from the water, and even in the same pipe with a playing fountain.

"The constant varying of the flames in rooms and gardens, between flaming pyramids, festoons, garlands, roses, flambeaus, &c., &c., afford to the spectator an extraordinary and most delightful sight; cherish the soul, and create good humour, by uniting conveniency, utility, and pleasure."

So runs this rhapsodical description, with more in the same strain regarding the advantages of the new process for health and cleanliness. Lebon's account of his invention is also reproduced, and the pamphlet concludes with what is called an

ACCOUNT CURRENT OF PROFIT AND LOSS.

"Anxious," says the author, "to bring everything home to the understanding of my readers, and to render it as clear as possible, I shall be very explicit in every item of the Account Current, by reducing it into a mercantile form.

"The expense of our usual kitchen grates and patent stoves, differing in price, as to size, usefulness, and elegance, say from one to a hundred guineas and upwards, I shall not bring them into the account, neither of the old smoking stoves, nor of the Imperial Light Stoves, but only state the expense and saving of fuel in both.

Account of Common Stoves and Lamps.

Debit.

a. To costs of coals, or any other fuel in a middling family, on an average during the year	£20	0	0
b. To costs of candles and lamps, ditto	10	0	0
	£30	0	0

Per Contra Credit.

c. By the value of heat and light the above coals and candles produce in the usual stoves, lamps, &c.	£30	0	0

N.B.—The value of cinders or ashes is nothing, because the dustman gets a Christmas-box for taking them away.

Account of Imperial Light Stoves.

N.B.—The expense for our usual stoves, lamps, and candlesticks, not having been charged in the former account, we cannot charge those of light stoves, and ornamental utensils, for lighting and warming rooms, in this account, because the one balances the other; and when they are once established in a house, they will serve always.

Debit.

d.	To costs of fuel for a middling family per annum .	£5	0	0
	To costs of candles and lamps, for moving about to light the others, &c.	1	0	0
		£6	0	0

Per Contra Credit.

e.	By value of light and heat in the common mode .	£6	0	0
f.	By ditto from the *extra* mode three times more heat .	15	0	0

N.B.—To render this the more intelligible, we must tell the reader that, by a peculiar construction of the stove, all kinds of fuel will either last *four* times as long, or will give *four* times the degree of heat; hence that heat may be used either in *quantity* or *quality*, just as suits our purpose and convenience.

A simile may illustrate this point still more forcibly. Supposing any brewer or distiller finds out a new method to extract from his malt or corn, a beer or spirit four times as strong as in the common mode; he will surely reap the benefit from it either in the *quality* or *quantity* of his liquors. By a slower degree of heating, he will extract four times as much of the usual strength; and by a stronger degree of heat, he may produce a four times stronger liquor, and reduce it to the common standard by three parts addition of water.

The same principle and method of saving fuel has already been so much illustrated and proved by the publications and improvements of Count Rumford, and other ingenious men, that I need not add any other testimony in its favour.

g.	By half the value of excellent charcoal or coke from the fuel	2	10	0

N.B.—From the method of carbonizing, the fuel is neither consumed, nor lost in cinders and

Carried forward, £23 10 0

Brought forward,	£23 10 0
ashes, but reduced into charcoal and coke; half of which quantity is more than sufficient to heat the stove next time for carbonizing fresh fuel, &c.	
h. By the value and use of hot smoke extracted from this fuel	5 0 0
N.B.—On the principle of Count Rumford and others, all kinds of fuel produce $\frac{5}{8}$ths parts in hot smoke, which, led into a proper machine, cistern, or bason, will answer all the purposes of a steam kitchen register stove, to cook, boil, bake and stew all kinds of victuals; to heat water for washing, bathing, &c., of course it may be made serviceable to the value of 100 per cent. heat.	
i. By value of the refined smoke into gaz, or inflammable air, which furnishes much *more* than *double* value in heat and light of the above six pounds worth of coals, say only double . . .	12 0 0
N.B.—On extra occasions, this inflammable air may serve for boiling, stewing, frying, nay, even for roasting, with a proper apparatus. For instance, I have often led it in a small tube from the kitchen below stairs, under a table into the parlour, to light or burn through four candlesticks at the four corners, and to burn in the middle of the table under a glass globe, which gives heat, equal to any stove, diffuses plenty of light through all the room, and serves to boil water, or warm dishes of all kinds upon. Hence, a small portion of inflammable air may, at *any* time, be led from the kitchen to *any* room, to be applied for cooking, heating, and lighting, at the same time. This same experiment to be repeated every day and evening during the exhibition.	
k. By the value of oil and pitch, to be collected from the condensator (part of the apparatus) in equal estimation with the coals . . .	6 0 0
N.B.—Lebon says, 'this oil or pitch considered as common tar only, is of great value.' But this being a far superior tar, from the peculiar mode of extraction, because it retains all the oily, softening, perforating, and astringent quality, it is to be supposed to fetch a greater price in the market than all common coal or wood tar, which loses all those subtle particles by evaporation.	
Carried forward,	£46 10 0

Brought forward,	£46	10	0
l. By the value of acid, which is a very powerful astringent lie, far superior to all kinds of bark in tanning skins, &c., estimated only at triple value of the coals	18	0	0
	£64	10	0

N.B.—This acid, if refined, becomes still more valuable in the manufacturing of white lead or verdigrease, in dying of black cotton, in curing and smoking of fish, beef, hams, sausages, &c.

" The other valuable applications which Lebon mentions, as to supersede the use of steam engines, gunpowder, &c., we shall not estimate, until some trials have been made of it in this country.

" From this estimate (which appears still undervalued) results, that the use of £6 worth of coals, or wood, may be so applied as to produce a saving and gain in produce, of above *one thousand per cent.*; yet supposing the real savings were only *one hundred per cent.*, surely it becomes of the greatest national value and importance, and may be made a source of uncommon private wealth and prosperity, if properly taken in hand, and supported by men of spirit and fortune."

At the end of this pamphlet is the following notice :

" ADVERTISEMENT.

" Such Noblemen, Gentlemen, public or private Companies, or Individuals, who from witnessing the *uncommon* Effects of *common* Smoke, shall be convinced of the great Utility of this Discovery, and may have an inclination to embark some Property in this valuable Speculation, may be furnished with the sight of a written Plan for a *threefold* grand *National Establishment*, which, in the least of Success, must insure unexampled Advantages to the Proprietors ; and which opens still greater prospects, from the Variety of great Applications to which the celebrated Engineer Lebon alludes."

This extravagant and absurdly erroneous estimate, according to which a return of £64 10s. was to be expected from every £6 expended, does little credit to Winsor's business capacity. It is clearly the work of either a charlatan or of an ignorant enthusiast ; most probably, however, the latter, since Winsor seems to have acted in good faith throughout, and in full belief that the new process possessed enormous value. Moreover, his public utterances make it clear that his scientific knowledge was of the slightest ; although of his deficiencies in this respect he does not seem to have been aware. For example, in his *Plain Questions and Answers*, published in 1807, occur the following :

"*Q*. Then suppose a room full of gas, and you enter with a candle ?

"*A*. It would *never* inflame, because it is intermixed with the air of the room.

"*Q*. But is it not hurtful to respiration ?

"*A*. Not in the least ! On the contrary, it is more congenial to our lungs than vital air, which proves too strong a medicine, because it only exists from one-fifth to one-fourth in the atmosphere ; whereas, inflammable air exists above two-thirds in the animal and vegetable kingdoms, in all our drinks and victuals. It forms a part of ourselves."

In his lectures, moreover, he asserted that he had cured himself of a constitutional asthma by superintending the work at his stoves, and inhaling the "hydro-carbonic gas ;" and he invited any person afflicted with disorders of the lungs to attend at his house, and try the remedy gratis.

In 1806, Winsor commenced occupation of No. 97 Pall Mall, "late Star and Garter Hotel," the site of which is now occupied by the Carlton Club. Here he continued his lectures and experiments, and from thence a part of Pall Mall was lighted with gas on the 28th January, 1807, the main or service pipe employed being made of lead. It was shortly after this, apparently (for the documents are undated) that he published his proposals for the formation of a National Light and Heat Company, setting forth in detail the enormous profits that were likely to ensue. In a circular letter which accompanied this prospectus, Winsor, after mentioning that his "Discovery" had secured the approval of various distinguished personages, including "their R.H. Dukes of Kent and Cambridge, . . . and others too numerous to mention," says : "I have made great improvements in my Patent Light Stoves, purified the Gas Lights from all scent, and increased their lustre.

"Persuaded of immense advantages and encouraged by numerous friends, I beg leave to offer you the enclosed Plan for a profitable National Company, because most Institutions owe their rise to the support of great Philanthropic and Commercial Men, such as I have now the honour of addressing.

"With the patronage of you and your friends, a National concern will soon be raised to open a mine of wealth in Britain, and add to the despair of our foes in their devices for our ruin.

"Above a thousand shares are already bespoke : . . .

"Two houses are now fitting up as standards for a general introduction of Gas Lights, clarified to their utmost brilliancy.

"The 5 pound deposit will suffice for realizing the plan in London and its environs, and all further sums wanted will prove but a *small deduction* from *speedy profits*.

"The official Experiments, as the basis of my *greatly undervalued estimates*, will be repeated to any number of subscribers."

In a second, and apparently later, circular he says that "The Patent having been vested in the hands of four respectable Gentlemen, as Co-proprietors, agreeable with the Patent Law, and the business appearing of such great *National Concern*, it is now proposed, agreed to and allowed, to establish a *National Company* by an *Act of Legislature* as a separate and *distinct National Institution*, from the Patent privileges, for which purpose the Co-proprietors now offer all the different advantages which will accrue to the Company from the supplying of Gas Lights, in the manner now proposed, and which advantages are sufficiently explained in Tables A, B & C in my Publication.

" It is further to be remarked, that by the adoption of this Plan now voluntarily offered to the Public, the Government will receive a very important addition to the Revenue, as plainly appears by Table D of the said Publication. Conscious of the *immense public* Benefits that must arise from a *general application* of the discovery, the Co-patentees do not wish to engross the whole of their Patent privileges to themselves, but to *share them* with a large and respectable number of their own Countrymen, in the following manner." Here follows the scheme for the establishment of the proposed Company, which was to have a nominal capital of one million pounds sterling, "to be secured by easy shares of Fifty Pounds, of which only £5 deposit" was required. The patentee was to have one per cent. of all the "emoluments" of the Company for " relinquishing the most valuable parts of his privilege, and for his great expense in numerous costly experiments and trouble, together with £4000 of his disbursements, during almost 5 years' constant trials." This latter reference seems to fix the date of these publications as either the end of 1806 or the beginning of 1807, since Winsor's connection with Lebon's Thermolamp commenced in the spring of 1802. The promoters or co-proprietors were also to be given shares in the Company of the value of £700, and also such further shares, to represent the expenditure necessary, " to render this plan complete from the *inspection* of the Public;" such expenditure not to exceed one thousand pounds.

In a third circular Winsor gives a " recapitulation " of the " details " on which his scheme is founded, from which, he says, " it is evident, that after a general application, each share of £50 must yield a yearly interest of £6000, worth in capital £120,000 ; but reducing my estimate to one-quarter profit, each share yields £1500 interest, worth £30,000 capital ; yet on estimating the profits at one-tenth only, each share gives £600 interest, worth £12,000 capital, and at this reduction would be equal to the highest present prices of *the New River* Company's shares, which are the most profitable now extant."

The " Publication," in which are given the details of Winsor's estimates, is entitled

A NATIONAL
LIGHT AND HEAT COMPANY
FOR PROVIDING OUR
STREETS AND HOUSES
WITH
HYDROCARBONIC GAS LIGHTS
On similar principles as they are now supplied with water.

Attention may be directed to the latter statement, as indicating clearly what Winsor had in mind, namely, a public supply of gas. This is also indicated in his scheme for the formation of a company, in which it is declared "that the great National object of this Establishment refers . . . to the providing Streets, Squares and Houses with Gaseous Lights by means of conducting tubes under Ground from distant Furnaces." This marks a distinct advance upon any previous proposals in connection with the subject, notwithstanding Clegg's essay at Manchester, already referred to. With this exception, nothing had been done in the way of distributing gas, and it does not appear that Murdoch ever contemplated doing anything in this direction.

Winsor commences by entreating "the reader to attend to the official experiments, made at the Lyceum. They clearly proved that two pecks of coal produced the value of 6s. 5d. in products during the space of a few hours, which is at the rate of £23, 2s. per chaldron. Now have the goodness to apply the simple rule of three, viz.:

If 1 Ch. contain £23, 2s., how much contain 10,500,000 Ch., the annual average consumption of the Realm?

Answer	£242,550,000
Deduct the cost of Coal and Carbonizing as per Table C.	13,196,373
Net annual profits agreeable to the official experiments	£229,353,627

"But my Estimate Tables will show how many allowances, deductions and undervaluations I have made for contingencies, to reduce the above enormous sum to one-half—viz., to £114,845,294. Now, if my readers will search for, and collect all further objections they can possibly imagine, I will abate $\frac{9}{10}$ths of the last sum, and the remaining tenth must insure them an annual interest of £570 for every £5 deposit, soon after the complete Establishment of this Company according to my proposals."

The following is given as an "Extract of the Minutes of a Sub-Committee appointed to examine and verify my discovery by two different experiments on the 20th and 27th October at the Lyceum. . . .

"Average produce of 36 lbs. or 2 pecks of coal, carbonized in the Patent Light stove:

lb.	oz.		
24	2	or 3 pecks in measure of fine patent Coke, *Proved* to increase 50 per cent. Estimated by me at only.	33 per cent.
3	12	of fine empyreumatic Oil-tar, for painting, &c., *Proved* to contain $\frac{1}{10}$th of its weight. Estimated by me at only	$\frac{1}{12}$th ,,
4	6	of Ammoniacal Liquor for Salts, &c., Proved to contain $\frac{1}{8}$th of its weight. Estimated by me at only	$\frac{1}{9}$th ,,

lb.	oz.		
3	12	of Inflammable Gas, Proved equal to 40 lights or 5 lbs. of Candles worth 5s. Estimated by me as the value of coal at only	£0 0 10
36	0	being the whole weight and substance of the above two pecks of Coals.	

Valuation of the said Products, which in its raw state cost at the highest 10d., being at the rate of 5s. per sack, or 60s. per chaldron, or 36 bushels of coal.

lb.	oz.		
		3 pecks of patent Coke, a far superior fuel of double heat ; estimated as only coal . .	£0 1 3
3	12	of Patent Oil-Tar, a far superior paint of double force; estimated as common coal-tar at 15s. per 112 lbs.	0 0 6
4	6	of patent Ammonia of great strength and pungency; estimated at 1s. per gallon . . .	0 0 6
3	12	of patent Hydrocarbonic Gas, brilliantly burning, equal to 40 Candles of 5 lbs. weight at 10d. .	0 4 2
		Total value of products	£0 6 5

Hence deducting 10d., the cost of Coal, there remains 5s. 7d., or 970 per cent. profit. Besides the double heat of Coke, the great heat of the process, and the heat of the lights, all of which would turn to a profitable use in houses and manufactories."

In Table A, which is described as an " Estimate of the immense Saving and Profit, on the general application of this Discovery throughout the United Kingdom," Winsor deals first with the consumption of coal in and about London. Assuming this to be 1,000,000 tons per annum, this quantity would, " in my Patent Process of Carbonization, decomposition of smoke, &c., yield the following valuable products : "

1,500,000 tons *measure* of superior coke, but allowing the increase of 500,000 tons measure, for combustion and waste, say one million tons. " Hence 133 one-third tons weight of Coal, allowing 25 Cwt. to every Chaldron, will give us 100 Chaldrons ; we obtain from the London consumption of 1,000,000 tons, 750 Chaldron measure of Coke, value instead of 48s. or 50s. the present prices, only at 30s." . .	£1,125,000
100,000 tons of " empyreumatic Oil-Tar, being one-tenth of the whole weight of Coal." . . .	
Carried forward,	£1,125,000

Brought forward,		£1,125,000
"Though the common Coal-Tar is sold at £14 per ton, and mixed with certain colours as high as 1s. 6d. per lb., I shall estimate this at £10 only"		1,000,000
"Nearly 100,000 tons of Ammoniacal liquor which when crystallized with Salammoniac only, is worth £10, 10s. per cwt., and may be made into still more valuable salts ; I shall only value at £10 per 250 gallons"		1,000,000
"More than 7,500,000,000 cubic feet of hydrocarbonate Gas, the value of which I have endeavoured to approximate by the proportion of one bushel of Coal, yielding more or less 8s. in pure light, since by repeated experiments with 2 pecks of Coal, I have obtained from 40 to 50 lights, equal to 8¼ lbs. of Candles at 1s. in duration, but much more brilliant in flame. However, I shall rate the light at 5s. value per bushel, and allowing 25 cwt. per chaldron of 36 bushels (though some coals will weigh near 28 cwt.), we have 27 millions of bushels, at 5s. each"		6,750,000
Total saving for London and its environs		£9,875,000
Multiplying this for the whole Realm by 13, as the ratio of the number of inhabitants, we obtain the total produce for the country of	£128,375,000	
But allowing for lower prices in the country of coke and tar, say one-third	9,208,333	
Leaves the reduced country proceeds at		£118,166,667
"Which gives the grand total saving and profit for London and country"		£128,041,667

This, however, was subject to deduction for working expenses and first cost of establishing the process, the estimate of which, according to Table B, was as under :

For London and Environs.

First Cost.—Furnaces and light sheds to cover the apparatus and products, including the necessary tools		£78,775
Annual Cost.—750,000 chaldrons of coal at the highest summer prices 40s.	£1,500,000	
(Winsor suggests that if the Company employed their own vessels,&c., from 10s. to 15s. per chaldron might		
Carried forward,	£1,500,000	£78,775

Brought forward,	£1,500,000	£78,775
be saved; while by owning mines, the saving would be increased.)		
Labour, repairs, rent, rates and taxes, and general expenses . . .	121,375	1,621,375
		£1,700,150
For the Country.		
First Cost.—Furnaces and light sheds at ½ the cost of the London plant . .		£957,287
Annual Cost.—9,750,000 chaldrons of coal at 20s. (½ cost in London) . .	£9,750,000	
Labour (at ½ the rates estimated for London), repairs, rent, rates and taxes, and general expenses . . .	788,936	10,538,936
Total cost for the country .		£11,496,223
Total cost for the whole realm .		£13,196,373
Deducting which from the annual "profit" left a "Grand Balance and profit for the Realm, near one hundred and fifteen millions," or, to be exact . .		£114,845,294

Table C is an "estimate of all the Wax, Spermacetti, Tallow, Oil, &c., annually consumed in the United Kingdom" for light-giving purposes, the total of which is £98,049,166. He sets off against this the value of the light to be obtained by carbonizing all the coal annually consumed. This he estimates at £151,200,000, showing "a surplus of £48,713,225, in light" by his process, "which would afford a very superior Brilliancy, not only to our Cities, Towns and their Environs, but would suffice to light up all the High Roads of the Empire besides."

Winsor then, in Table D, develops his scheme for "the increase of Revenue and the fairest means of introducing a general application of this Discovery, by the Laws of the Realm."

"Four, five, or six months after passing the new law for the general use of heat and light from Coke and Gas, a Tax of 3½d. per bushel, 10s. 6d. per Chaldron," in London, and of half these amounts in the Country, "for all further burning of crude Coal. This tax," he says, "cannot be oppressive in the least, because it falls on the obstinate only, who shall resist the use of a far superior, cheaper, and safer fuel."

"Being an easy and gratifying addition to our National Revenue of	£1,476,562
Carried forward,	£1,476,562

Brought forward,	£1,476,562
" But in proportion as this tax decreases by a more progressive adoption of the use of Coke and Gas, is to be paid by the Company with 20 per cent. addition, which in case of general use would be a further annual sum of	315,312
" All those desirous of having their houses supplied with patent coke, to give an estimate (even on oath if required) of the quantity of coals they used to consume during the last years, and the prices paid for them ; for they will receive the same in measure of Coke, which gives *double Heat* and a clear fire, at 20 per cent. cheaper." Winsor next proposes that " During four months after passing the said new law, every House Keeper and Lodger to be obliged to give a fair estimate on oath, if required, of the quantity of Candles or Oil consumed by him and his Family, and six months after the date of the Act, if his house or apartment is not fitted up to be supplied with Gas, a Tax to be paid of 2d. on every pound of Spermacetti, and Wax Candles, and on each pint of fine Lamp Oil consumed in Chandeliers, Lustres, Halls, Passage Lamps, and every other place where light is generally kept and wanted as a *fixture*," allowance to be made for candles or oil used for portable lights. He suggests that the collecting of these taxes might be facilitated by means of stamps affixed to every parcel of candles and every bottle of oil sold, " the same as advertised medicines are vended at present." Or instead of stamps " an adequate impost might be levied from every House Keeper and Lodger, for each Room, Hall, Kitchen and Passage, not provided with Gas Lights." " This tax on objecting to the Gas Light might," says Winsor, " become very productive, and perhaps bear a tenfold proportion to that of Coal before the new laws would be generally obeyed." But he modestly rates it at a five-fold production of the coal tax for the first year of its commencement, or . .	8,959,370
Adding to this the proceeds of the coal tax, a total is obtained of	£10,751,244

" Which," he observes, " would be a handsome revenue for the first year of the new tax, and perhaps enable Ministers to dispense with any other real burthens to be laid on the nation." Mark the naïve admission that these taxes would constitute a *real* burden.

"In proportion as this Tax (*sic*) decreases by the progressive use of the new mode of Lighting, a reasonable percentage might be allowed to Government by this Company, because they could then well afford the same, as it would be but a small deduction from their immense profits."

He repeats in conclusion, that "if all the objections to this scheme were valid and amounted to $\frac{9}{10}$ths or even to $\frac{19}{20}$ths part in the reduction of my estimated profits, yet the remaining $\frac{1}{10}$th or even $\frac{1}{20}$th part of the sum must insure an annual income of near £600 in the first, and near £300 in the last and most hazardous instance, for every five pounds adventure. Hence all Traders in raw fuel, Oil, Wax, and Tallow will have an easy opportunity of securing to themselves and families a much nobler provision than they could possibly obtain by several years of successful drudgery."

The pamphlet winds up with a challenge to "the most able calculators to *disprove* my Estimates, or the most scientific and philosophical Chemists to *disqualify* my official Experiments on which those estimates are founded." This overweening confidence also finds expression in his rebuke to those who ventured to suggest "that my calculations of Profits appeared too wonderful to be true." "To all similar remarks," he says in one of his advertisements, "I must beg leave to reply, that the annual course of our Planet round the Sun, and its diurnal rotations round its axis, have appeared, and do appear, still more wonderful than my tables of profit; but they are nevertheless true." At the same time, he admits elsewhere that "the attempt to eradicate old-established customs and prejudices, imbibed as it were from the very cradles of our great-grand-sires, who inherited them from Adam, or since the beginning of the world; such an attempt may be called a Herculean task." The year 1807 was a busy one with him, having regard to the number of his pamphlets bearing that date. One of these has no reference to gas, being a proposal for the establishment of a National Deposit Bank, to have for its object the affording of accommodation to merchants wanting loans on goods, and the lending of money on landed free and leasehold property, incomes, pensions, reversions, &c. In another pamphlet he advocates the use of his Patent Light Stoves in Green and Hot Houses, which he concludes "must be very beneficial; as by their operation the principal nourishments for vegetation, such as Light and Caloric, Hydrogen, Nitrogen, Carbonic Acid Gas, &c., are plentifully generated, and may be applied without interruption in a much greater proportion than even the most powerful action of solar rays can possibly produce, in the common operation of nature." In that year appeared also his *Plain Questions and Answers*, already referred to. In these he expresses the opinion that so far from the introduction of gas lighting being likely to "hurt our fisheries, oil and tallow trade, &c., nurseries of seamen, &c., they must increase by it, because, from saving so many new products at home, we increase our exportations; we can afford to undersell in every foreign market all we gain from worse than nothing, from miserable smoke. We can employ hundreds of more vessels, and thousands of more seamen, for the benefit of our nurseries." As to the tallow-chandlers, oilmen, wick and snuffer makers, &c., "they may all work for exportation; that is, either become exporters themselves, or sell to merchants who export in general. Thousands of chests, containing from 20 to 100 dozen of indifferent candles, are anually sent from Russia all the world over. I trust England may command the foreign markets with superior candles at a cheaper rate." As to the lamplighters and chimney-sweepers, "the former will light *cleaner* lamps in a *cleaner* dress, and no longer annoy the street passengers with the smoke and dirt of train oil. As for the poor chimney-sweepers, I hope they will get a more *Christian-like* employment." Opposition to his scheme he does not apprehend "from sensible and enlightened persons," and is "fully prepared to meet and refute all *obstinacy, prejudice, ignorance*, and *malice*" . . . "by public conviction with my experiments; by the good sense of the majority in the nation; by the self-interest of individuals; and lastly, by the protection of Parliament, and the support of the enlightened public. I hope," he continues, "from the wisdom of the Parliament of England, the protection of every measure beneficial to the country. If the wisdom of a British Parliament could ever enforce a law for the button-makers, and oblige Englishmen to wear metal instead of cloth buttons, surely the wisdom of the same Legislature will be more feelingly alive to a far *superior* saving from the destruction of the greatest nuisance (coal smoke) this metropolis and country have been infested with for about five centuries, Parliament will know how to appreciate so much real saving."

"The foundation of the National Light and Heat Company," he declares, "is more solid than any other establishment whatever; it has no risks of any kind; it exceeds in benefits the *Water Companies*, by gaining four valuable products from the destruction of a great nuisance—that of smoke. These products amount to above £20, in every chaldron of fuel, and can be made from three to four times in twenty-four hours." In a footnote to this he states that "three years since, £10,000 were subscribed, by one hundred candidates, to form a Coke Company, because many of those gentlemen were fully persuaded, that my *Coke* being introduced, would alone make their fortunes. But this product is only the seventh part of the whole saving." In the conclusion to this pamphlet he asserts that "the *National Light and Heat Company*, being founded on a *patent invention* and *privilege*, is certainly more secure than all our flourishing *Insurance* and even *Water Companies*." No further calls are to be made on the subscribers, "because, by my calculation, we have money enough with 20,000 (five pound deposits) to begin our operations in several houses, manufactories, streets, and parishes. From these profits we can *gradually* deduct any further instalments to make up the £50 capital, if this should ever be wanted."

Not contented with these prose efforts of imagination, Winsor tries verse, of which the following is a specimen:

" Must Britons be condemned for ever to wallow,
In filthy soot, noxious smoke, train oil, and tallow,
And their poisonous fumes for ever to swallow;
For with sparky soot snuffs, and vapours men have constant strife,
Those who are not burnt to death are smothered during life."

Again:

" Most mortals on earth with smoke live in strife,
And many a beauty is smothered alive,
Great London itself th' empor'um of the world,
In clouds of black smoke is constantly furl'd."
" Smoke begot chimneys, chimneys beget smoke,
Soot, fires, and filth all prevented by coke."

This dropping into poetry, as Mr. Silas Wegg would have called it, can hardly be described as an improvement in style, and it seems to have had no effect in allaying the strong opposition which his proposals aroused. We find him engaged in defending these from the attack of no less a person than Mr. William Nicholson, a well-known scientist of the day, and proprietor and editor of Nicholson's *Philosophical Journal*, in the pages of which there appeared, on the 1st January, 1807, a scathing criticism of his scheme. It was easy enough for his critic to show that there was nothing new in the production of light from gas obtained from coal, but Winsor's reply is worth quoting. " The history and invention of Gas Lights," he says, " which Mr. N. attributes and confines to Messrs. Diller, Murdock, &c., I proved in my lectures at the Lyceum three years ago, to be of a far more ancient date. I commenced my History of Light, Heat, Fire, and Flame, from the Persian Sages, and finished with Boerhaave, Sir Isaac Newton, Priestley, Lavoisier, Baron Haak, General Conway, Lord Dundonald, Count Rumford, and other reformers in modern chemistry. I confess I have never read or heard of the works of Messrs. Diller, Murdock, &c., on Gas Lights, and the saving of *Heat and Fuel*, for which the above-mentioned gentlemen were so celebrated."

Mr. Nicholson's criticisms were mainly directed to the validity of Winsor's patent, the financial aspects of his scheme, and the hazardous nature of the security on the faith of which the public were asked to subscribe. To all of his objections Winsor made answers, doubtless sincere even in their extravagance, and wound up by saying:

" I shall always be happy to meet any opponent, on *real* scientific grounds, in a gentlemanlike controversy, but all

" Attacks unletter'd, I did ne'er provoke,
I'll shame by silence, or by satire joke."

" The *gaseous* crackers in the *Philosophical and Chemical Journal* have excited smiles of compassion and shrugs of shoulders from every subscriber to whom I have as yet had an opportunity of shewing them ; and to give still more publicity I mention them to my numerous auditors every lecture night. They strengthen my friends in their conviction, and produce *second*, and even *third*, subscriptions. It is thus that *solid demonstrations* must ever triumph over conspiring envy, prejudice, and ignorance. So perfectly do I feel myself master of my own subject, that I can ' smile like patience on a monument,' on the opposition of all prejudiced F.R.S.'s, B.A.'s, M.A.'s, schoolmasters, professors, and journalists."

As if this were not enough, he lashes the offending Mr. Nicholson with the following verse :

" Nicholson & Co. are hunting, coursing, and fishing,
For legal flaws,
In patent laws,
To defeat the inventor's plan, for they are wishing,
Winsor to lose his just applause.
But let Britons be told that when of millions they dream,
In many a tedious, doubtful, transatlantic scheme,
Millions at home are wasting in noxious soot and smoke,
Which may be realized in costly light, tar, and coke."

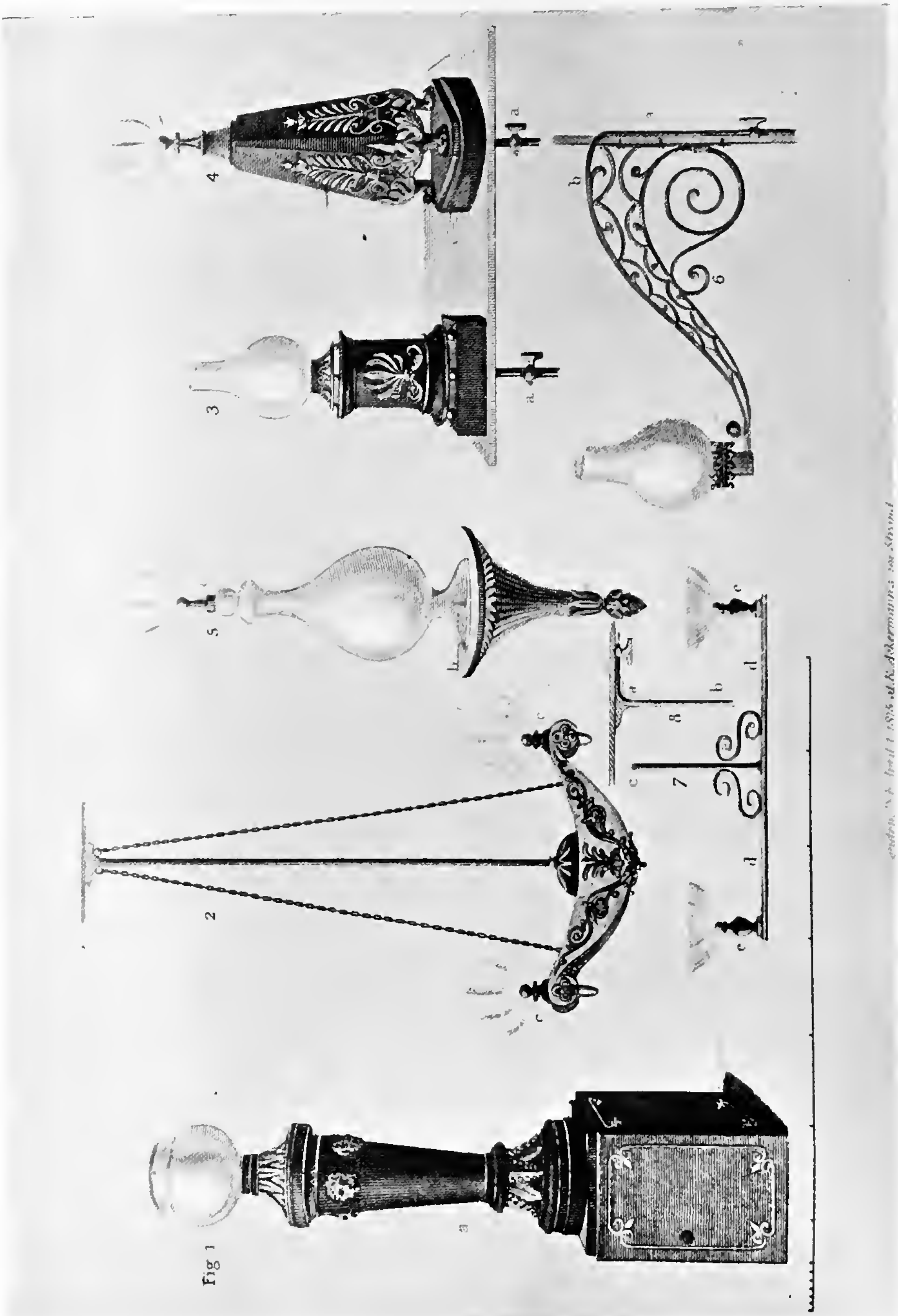
It is quite conceivable that the attacks on Winsor did, as he asserts, actually help his cause, by bringing it into notoriety. About this time, also, an attempt was made by Alderman Wood and others to light with gas the Golden Lane Brewery, and a part of Beech Street and Whitecross Street. This appears to have been regarded by Winsor as an infringement of his patent.

In 1808 there was published a satire entitled

AN
HEROIC EPISTLE
TO
MR. WINSOR,
THE
PATENTEE OF THE HYDRO-CARBONIC GAS LIGHTS
AND
FOUNDER OF THE NATIONAL LIGHT
AND HEAT COMPANY.

This effusion is accompanied by a vulgar caricature by Gilray, printed in colours, and which is intended to represent an experiment performed at a meeting of the Royal Institution. It is entitled " Scientific Researches ! New discoveries in Pneumatics ! An experimental discourse on the powers of air ! "

In his "Advertisement to the Reader," the anonymous author makes fun of Winsor's " Patent Lamp," by the light of which much of the poem is stated to



SAMPLES OF GAS FITTINGS AS ILLUSTRATED IN ACCUM'S "TREATISE ON GAS LIGHTING," 1815.

have been composed, asserting that on one occasion his laundress "mistaking the end of the gas tube for a lamp wick, and officiously intending to snuff it with her scissors, cut my gas pipe in twain, by which means my room (an attic) was filled with inflammable air, and I, my laundress, and our cat, were almost suffocated."

The poem, which is of considerable length, commences by hailing Winsor as the

"Hesper of Science! philosophic light!
Like Newton sent to illumine Britain's night,
To pure Caloric change Augusta's smoke,
Her soot to æther, and her coal to coke,
Bid noxious fumes impart a vital gale,
And morbid lungs *Carbonic* health inhale,—
Thee I address! dispel thy frown severe,
Nor deem the opposer of thy patent, near;
Know! that 'gainst genius of such giant size
(A blaze of evidence before my eyes),
Committees, gifted with discernment keen,
And faith (the evidence of things not seen)
'Gainst proof and inference of such high pretence,
'Twere vain to urge the doubts of common sense,
And far from me the wish, with satire's jibe,
To censure schemes to which I can't subscribe;
Mine be the task to fumigate thy fame,
With incense kindled at the Muse's flame."

As a sample of the ridicule with which the poem seeks to cover each of Winsor's proposals, the following may suffice. It relates to the proposed use of the new gas lights for "hot and green houses:"

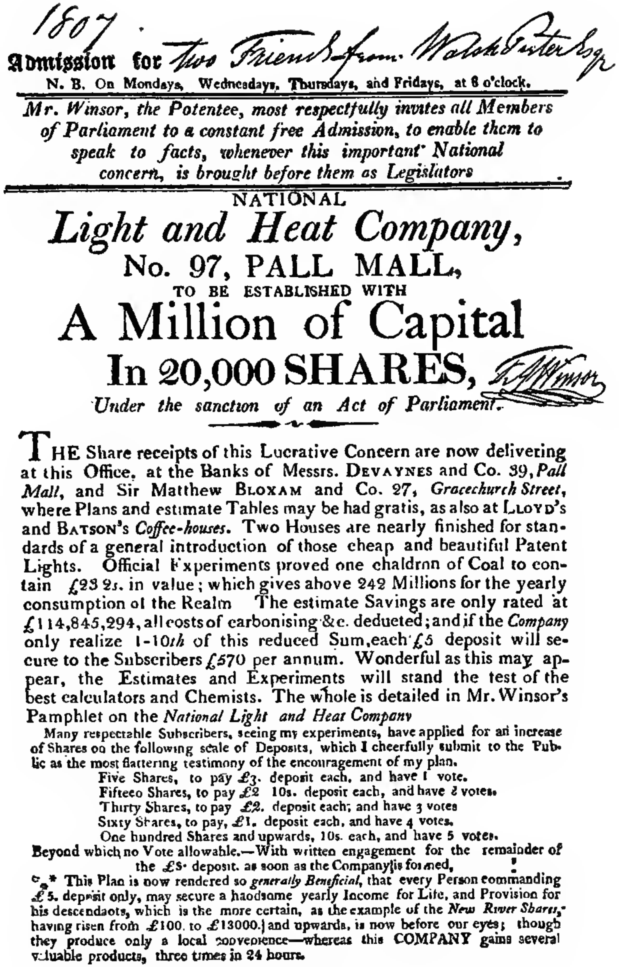
"Thee all the vegetable world shall praise,
And on thy altars hot-house incense blaze,
Exotic seedlings rising from their bed,
Shall o'er thy flues their early perfumes shed,
No leaf for lack of Hydrogen complain.
No flow'ret droop 'in aromatic pain;'
Thy heat *more genial* than the solar ray,
Shall vivid hue and fragrant scent convey;
Cheer'd by thy Gas shall groves of cresses rise,
And girkins rival cucumbers in size;
Mushrooms no longer skulk in earth like moles,
But like impatient *buttons* burst their holes;
Young thistles forced, shall artichokes become,
And laurels 'drop a medicinal gum;'
Heaths turn'd to underwoods for lopping call,
And groundsel and ground-ivy top the wall,
Toadstools and puff-balls, which, for want of care,
Now 'waste their sweetness in the desert air,'
Shall with their tribe of fungi quit the field,
And, stoved by thee, *cephalic* odours yield;

Mustard unmade its pungent powers disclose,
And peppers take the gardener by the nose;
To meet thy flame the Heliotrope shall turn,
And for thy gas with Clytie's passion burn;
Nourished by thee each plant to seed shall run,
And in thy system hail another sun!"

The concluding stanza runs thus:

"And when—ah Winsor! distant be the day,
Life's flame no longer shall *ignite* thy clay:
Thy *phosphor nature*, active still, and bright,
Around us shall diffuse *post obit* light;
Perhaps, translated to another sphere,
Thy spirit like thy light refined and clear,
Balloon'd with purest Hydrogen shall rise,
And add a Patent Planet to the skies;
Then some sage Sidrophel, with Herschel-eye,
A bright Winsorium Sidus shall descry;
The vox stellarum shall record thy name,
And thine outlive another Winsor's fame!"

We give here a facsimile of one of Winsor's cards of admission to his lectures at No. 97 Pall Mall, with his signature attached. This card is printed on both sides. On one side are set forth the advantages which are to accrue from the formation of a National Light and Heat Company, with the statement that these are the more certain, "as the example of the *New River Shares*, having risen from £100 to £13,000 and upwards, is now before our eyes, though they produce only a local convenience—whereas this Company gains several valuable products, three times in 24 hours." On the other side is a description of the exhibition provided in addition to the lectures and experiments. This included various rooms fitted up to show how they could be lighted and warmed. Thus there was a saloon "containing a most curious and superb grand Chandelier, equal to 150 Candles, proving how magnificently all Theatres, Ball and Concert Rooms may be illuminated," also committee, drawing, and dining rooms, fitted up to show the suitability of gas lights for both business and domestic purposes. Some idea of these fittings may be gained from the accompanying illustration (p. 112), which is a reproduction from Accum's *Treatise on Gas Lighting*, published in 1815. Winsor, in fact, left no stone unturned to demonstrate the great value and public importance of the new process; and his boldness and resource, and the unflinching zeal with which he encountered all opposition, are deserving of the fullest recognition and the highest praise. These are just the qualities that were necessary for the successful advocacy of a scheme which most people regarded as visionary, and which the leaders of the scientific world denounced as fraught with great danger to the community. They do much, indeed, to redeem the grotesqueness and extravagance of his assertions and figures, although these were, in



1807 ·

Admission for two Friends from Walsh Porter Esq

N. B. On Mondays, Wednesdays, Thursdays, and Fridays, at 8 o'clock.

Mr. Winsor, the Potentee, most respectfully invites all Members of Parliament to a constant free Admission, to enable them to speak to facts, whenever this important National concern, is brought before them as Legislators

NATIONAL

Light and Heat Company,

No. 97, PALL MALL,

TO BE ESTABLISHED WITH

A Million of Capital

In 20,000 SHARES, F A Winsor

Under the sanction of an Act of Parliament.

THE Share receipts of this Lucrative Concern are now delivering at this Office, at the Banks of Messrs. DEVAYNES and Co. 39, *Pall Mall*, and Sir Matthew BLOXAM and Co. 27, *Gracechurch Street*, where Plans and estimate Tables may be had gratis, as also at LLOYD's and BATSON's *Coffee-houses*. Two Houses are nearly finished for standards of a general introduction of those cheap and beautiful Patent Lights. Official Experiments proved one chaldron of Coal to contain £23 2s. in value; which gives above 242 Millions for the yearly consumption of the Realm The estimate Savings are only rated at £114,845,294, all costs of carbonising &c. deducted; and if the *Company* only realize 1-10*th* of this reduced Sum, each £5 deposit will secure to the Subscribers £570 per annum. Wonderful as this may appear, the Estimates and Experiments will stand the test of the best calculators and Chemists. The whole is detailed in Mr. Winsor's Pamphlet on the *National Light and Heat Company*

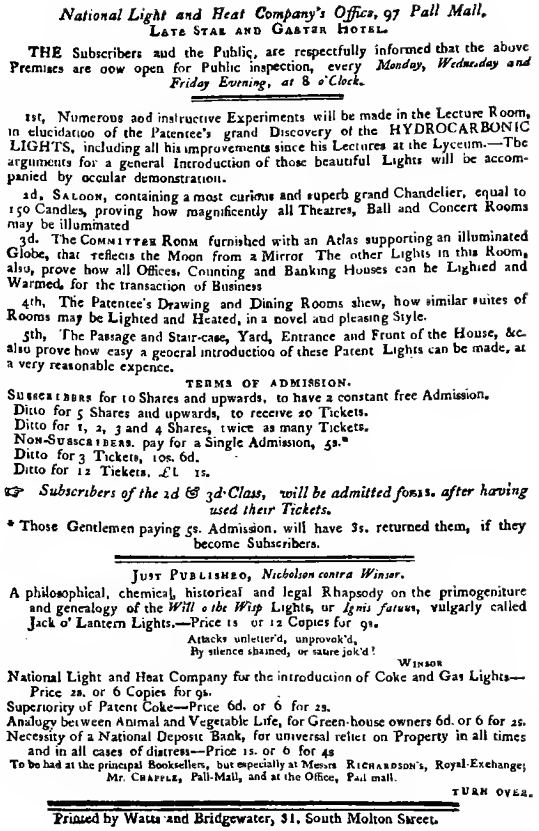
Many respectable Subscribers, seeing my experiments, have applied for an increase of Shares on the following scale of Deposits, which I cheerfully submit to the Public as the most flattering testimony of the encouragement of my plan.

Five Shares, to pay £3. deposit each, and have 1 vote.
Fifteen Shares, to pay £2 10s. deposit each, and have 2 votes.
Thirty Shares, to pay £2. deposit each; and have 3 votes
Sixty Shares, to pay, £1. deposit each, and have 4 votes.
One hundred Shares and upwards, 10s. each, and have 5 votes.

Beyond which no Vote allowable.—With written engagement for the remainder of the £5· deposit. as soon as the Company is formed,

*** This Plan is now rendered so *generally Beneficial*, that every Person commanding £5. deposit only, may secure a handsome yearly Income for Life, and Provision for his descendants, which is the more certain, as the example of the *New River Shares*, having risen from £100. to £13000. and upwards, is now before our eyes; though they produce only a local convenience—whereas this COMPANY gains several valuable products, three times in 24 hours.

FACSIMILE OF A CARD OF ADMISSION TO LECTURES AT NO. 97 PALL MALL, ISSUED BY WINSOR.



National Light and Heat Company's Offices, 97 Pall Mall,
LATE STAR AND GARTER HOTEL.

THE Subscribers and the Public, are respectfully informed that the above Premises are now open for Public inspection, every *Monday, Wednesday and Friday Evening, at 8 o'Clock.*

1st, Numerous and instructive Experiments will be made in the Lecture Room, in elucidation of the Patentee's grand Discovery of the HYDROCARBONIC LIGHTS, including all his improvements since his Lectures at the Lyceum.—The arguments for a general Introduction of those beautiful Lights will be accompanied by occular demonstration.

2d, SALOON, containing a most curious and superb grand Chandelier, equal to 150 Candles, proving how magnificently all Theatres, Ball and Concert Rooms may be illuminated

3d. The COMMITTEE ROOM furnished with an Atlas supporting an illuminated Globe, that reflects the Moon from a Mirror The other Lights in this Room, also, prove how all Offices, Counting and Banking Houses can be Lighted and Warmed, for the transaction of Business

4th, The Patentee's Drawing and Dining Rooms shew, how similar suites of Rooms may be Lighted and Heated, in a novel and pleasing Style.

5th, The Passage and Stair-case, Yard, Entrance and Front of the House, &c. also prove how easy a general introduction of these Patent Lights can be made, at a very reasonable expence.

TERMS OF ADMISSION.

SUBSCRIBERS for 10 Shares and upwards, to have a constant free Admission.
Ditto for 5 Shares and upwards, to receive 20 Tickets.
Ditto for 1, 2, 3 and 4 Shares, twice as many Tickets.
NON-SUBSCRIBERS. pay for a Single Admission, 5s.*
Ditto for 3 Tickets, 10s. 6d.
Ditto for 12 Tickets, £1 1s.

☞ *Subscribers of the 2d & 3d Class, will be admitted for 1s. after having used their Tickets.*

* Those Gentlemen paying 5s. Admission, will have 3s. returned them, if they become Subscribers.

JUST PUBLISHED, *Nicholson contra Winsor.*

A philosophical, chemical, historical and legal Rhapsody on the primogeniture and genealogy of the *Will o the Wisp* Lights, or *Ignis fatuus*, vulgarly called Jack o' Lantern Lights.—Price 1s or 12 Copies for 9s.

Attacks unletter'd, unprovok'd,
By silence shamed, or satire jok'd!
WINSOR

National Light and Heat Company for the introduction of Coke and Gas Lights—Price 2s. or 6 Copies for 9s.
Superiority of Patent Coke—Price 6d. or 6 for 2s.
Analogy between Animal and Vegetable Life, for Green-house owners 6d. or 6 for 2s.
Necessity of a National Deposit Bank, for universal relief on Property in all times and in all cases of distress—Price 1s. or 6 for 4s

To be had at the principal Booksellers, but especially at Messrs RICHARDSON's, Royal-Exchange; Mr. CHAPPLE, Pall-Mall, and at the Office, Pall mall.

TURN OVER.

Printed by Watts and Bridgewater, 31, South Molton Street.

REVERSE SIDE OF A CARD OF ADMISSION TO LECTURES AT NO. 97 PALL MALL, ISSUED BY WINSOR.

their way, of assistance in attracting attention to his proposals. If, as he himself argued, only one-tenth or one-twentieth part were true of the profit to be expected from the process, might it not still be said that there was in it the potentiality of wealth almost beyond the dream of avarice? Small wonder, therefore, that Winsor succeeded in enlisting the sympathy and support of a considerable number of subscribers, some of whom appear to have been possessed of considerable influence.

These, at a preliminary meeting, appointed a provisional Committee to inquire into the merits of the process; and this having been done, a general meeting of the subscribers was held at the Crown and Anchor Tavern, Strand, on the 24th July, 1807. It was then agreed "that it appeared, from a detailed official experiment made with Mr. Winsor's Patent Light and Heat Stove, that it can be used without danger or difficulty—saving the whole produce or value estimated by him—and offers the richest prospect of national and individual benefit." Further, "that £20,000, or one-fifth of the subscriptions, should be invested by Deed in a Committee for lighting a street in London and Westminster, for the grand object of obtaining a Charter of Corporation, to render this important discovery more generally beneficial both to the Government and to the Nation." The provisional Committee was continued, and twenty-five names were resolved upon for insertion in the deed, amongst these being J. L. Grant, the Chairman, the Duke of Athol, Lord Anson, and Baron Wolff.

Arrangements were made for receiving subscriptions, and for the election of honorary members, and it was decided "that the Committee should meet on Wednesday, the 12th August, at Mr. Winsor's in Pall Mall, at two o'clock precisely." This meeting may with reason be regarded as the first for administrative purposes held by the Chartered Gas Company.

The deed of trust above referred to marks an epoch in the history of Winsor's enterprise, which for the next few years is that of the Company thus inaugurated. Winsor's work is now taken up by others, and his hitherto conspicuous figure is henceforth less discernible in connection with it. To him, however, remains for all time the credit of having initiated the system of public gas lighting.

CHAPTER V.

MURDOCH AND THE STRUGGLE FOR INCORPORATION.

THE Trustees appointed at the meeting referred to in the last chapter had by no means an easy task, but they set about it with a will. Their object, as set forth in the report which they subsequently made to the subscribers, was " to assist Mr. Winsor in trying the power, operation and effect of his oven, stove, furnace and apparatus, and in defraying the costs and charges of his experiments, upon so extended a scale that it might be ascertained with precision, the advantage which might be derived to the public from his discovery and invention ; and also to pay all such legal expenses as he had or should incur in the prosecution thereof." Accordingly, they " proceeded to inquire into the practicability of lighting the two Houses of Parliament, Pall Mall, Grosvenor Square, Portman Square, Somerset House, Cheapside, the Mansion and India Houses, the Treasury, and the Bank of England ; but finding from the novelty of the undertaking, and the objections that were made to it, that these measures would be attended with considerable delay and expense," they decided " to confine their attempts to Pall Mall only." But even here they were not allowed to do all they wanted. Consent appears to have been given by the paving authorities for the erection of a few posts and the laying of the necessary services to them, but the Trustees lament that they were prohibited by the Paving Committee of the parish of St. James's from the further erection of their posts, &c., for the purpose of a display at the Club at Boodles,[1] for which the consent of its members had been obtained ; so that " the result of this so desirable an experiment has been completely lost to the public."

Every effort was made to advertise the scheme and obtain subscriptions, which, from the accounts subsequently published, amounted to £15,000. Of this only £5175, 0s. 5d. had been expended by May, 1808, including £1183, 7s. 5d. for law costs, part of which was incurred in the preparation of a petition for incorporation.

One principal means adopted by the Trustees for enlisting support to the scheme was by the issue, early in 1808, of a pamphlet entitled *Considerations on the Nature and Objects of the Intended Light and Heat Company.*

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[1] In St. James's Street.

In the "advertisement" to this, dated 12th February, 1808, it is explained that "the plan" of the intended "Company professes to increase the wealth of the nation, by adding to the number of its internal resources; and on this ground it is entitled at least to a candid examination. The object of the following pages is to rescue it from misconception and misrepresentation, and by a fair, and not overcharged statement of its merits, to appeal from prejudice and ignorance to the good sense of the community. The facts and principles on which it is founded have been long known, and partial attempts have been made to turn them to account. The time seems to have arrived when discoveries which have long been ripening, should be applied to some practical purpose; and if a strong case be made out, the promotors of the plan are justified in expecting the support of Parliament and of the Public."

That the Trustees were impressed with a due sense of their responsibility in dealing with this matter, is apparent from the moderation of their tone with regard to the part played by Winsor. "It is," they say, "needless to examine his (Winsor's) claim to the praise of invention; for where practical utility is the object, the public is not so much indebted to the man who hints obscurely at a truth, discovers some of its bearings, or illustrates it by a few barren experiments, as to him who presses it on their attention with persevering diligence, and, by experiments on a great scale, shows that it is capable of extensive application. Mr. W. made no new discovery with regard to the composition of coal; he did not even invent the mode of conducting the gas through tubes, but if he has simplified the process, and thereby lessened the expense of obtaining the products, he has made the most important, though not the most brilliant, improvement in this line of discovery. His publications, indeed, are but ill adapted to promote his cause, and the exaggerated calculations which the sanguine mind of a discoverer is naturally disposed to indulge in, have to superficial observers thrown an air of ridicule and improbability on the whole scheme. It may, however, be safely affirmed, that if the same discoveries had come forward under the sanction of some great name in the chemical or philosophical world, the public credulity would long since have been subdued; and the plan which for six years has been struggling for existence would have been eagerly adopted as a national object."

The Trustees had also the good sense to reject Winsor's proposal to tax coal, oil, and candles, being convinced, apparently, of the impossibility, "without an odious and oppressive excise, to levy a tax on this species of lights." Anticipating, however, a serious falling off in the revenue from a lessened consumption of oil and tallow "in proportion as the gas lights are generally adopted," they proposed as a compensation that the Government should share in the profits made by the Company, the latter to be chartered as an "exclusive" Company for this purpose. "It" (the Government) "will thus have nothing to fear, as one branch of the revenue fails, another, and a more productive, will supply its place." The object which these promoters had in view is thus made clear. It was the formation of a Company with a monopoly of the new process, in the profits of which the Government was to share.

After pointing out that by the new process the complete analysis of pit-coal—hitherto confined to the laboratory of the chemist—is simplified and made possible on a practical scale, "all the component parts being produced in their most useful shape, and at an expense out of all proportion below the value of the products," the pamphlet proceeds to give the result of experiment "not as being rigorously exact, but because it was performed in the presence of several intelligent and respectable gentlemen,[1] appointed by the Committee to verify Mr. Winsor's statements.

From 4 pecks or 1 bushel of Newcastle coals, weighing 69 lbs., value 1s. 6d., there were produced 4¾ pecks of well-formed coke, and ½ peck of coal not carbonized in the process, weighing together 58 lbs. 6 oz., valued at 1s. per bushel	£0	1	4½
6 lbs. 8 oz. of tar and ammoniacal liquor, value	0	1	1½
	£0	2	6
Deduct for coal	0	1	6
Profit on coke, tar, and ammoniacal liquor	£0	1	0
The gas yielded by the 4 pecks of coal produced 42 brilliant lights, which burned 7 hours. To keep 42 tallow candles burning for the same time would require 7 lbs., which at 1s. per lb. is	£0	7	0
To this add profits on coke and tar	0	1	0
Gained out of every bushel of Newcastle coal	£0	8	0

"The profits, of course, will be greater still if we compare the gas lights with the expense of spermacetti or wax candles."

A remarkably similar estimate of saving was published in Accum's *Treatise on Gas Light* seven years later, on the authority of Messrs. Lloyd of Queen Street, Southwark, "thimble manufacturers and whitesmiths, who have used the gas-light for soldering and other purposes these five years past." The similarity is so striking, in fact, as almost to suggest the same origin; but the particulars are given for what they may be worth.

From 4 pecks or 1 bushel of coals, weighing 69 lbs., for which we now pay (1809) 1s., we produce 4¾ pecks of coke, and ½ peck of coal not carbonized

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[1] J. L. Grant, Esq., Baron Wolff, Mr. Oliphant, and Mr. Hurry. The Duke of Athol and Dr. Jenner were present a great part of the time.

remains in the distilling pot, which together with the coke weighs 58 lbs. 6 oz., value 1s., at per bushel	£0	1	4
We procure 6 lbs. 4 oz. of tar, which we use as pitch—it saves us	0	1	0
	£0	2	4
Deduct for coal	0	1	0
Profit on coke and tar	£0	1	4
The gas yielded by the 4 pecks of coals in the pot made 42 brilliant lights, which burn 7 hours. To keep 42 tallow candles which were formerly used in the manufactory, burning for the same time, required 7 lbs., which at 1s. per lb. cost	£0	7	0
To this add profits on coke and tar	0	1	4
Gained out of every bushel of coal	£0	8	4

"The gas-burners made use of in our manufactory produce jets of flame, which in our business, where much soldering with the blowpipe must be done, have a decided superiority over Argand's lamps. We are not nice concerning the quality of the gas—a great part of it is burned from the gasometer, without allowing it to purify itself in the gasometer, because our gasometer is not large enough to store up the whole quantity of gas we want for use."

In neither of these statements is any deduction made for the cost of labour or wear and tear, nor is there any allowance for the fuel used in heating the apparatus, credit being taken for the whole of the coke produced. The coke and tar together amount to about 94 per cent. of the coal used, leaving only a little over 6 per cent. for the gas and ammoniacal liquor. In all probability, however, the weight of coal used was underestimated, since a bushel would be nearer 80 lbs. than 69 lbs. as stated. The value of the tar is estimated at nearly £18 per ton—a figure which in these days seems almost incredible. Winsor, however, speaks of it elsewhere as being worth 15s. per cwt., and Benjamin Cook refers [1] to an advance in the price of tar-spirit brought from Russia, from 3s. to 3s. 6d. to 20s. per gallon, "since the stoppage of trade from the North." Apparently, therefore, the price of tar did for a time rule high; although, on the other hand, Murdoch did not attach any great value to this product.[2] There can, however, be little doubt that the distillation of coal by various processes, chiefly for the sake of the tar, was for many years prior to the introduction of gas lighting a rather important industry.

After describing the nature and value of the products obtained, the pamphlet proceeds to announce that it has "been proposed to establish a Company; and if Parliament should sanction the establishment by granting a charter, the merits of the plan would soon be brought to a fair trial. If it succeed, the nation will be benefited by enjoying a superior light at a cheaper rate,

[1] See Chapter III. p. 80.

[2] See Chapter III. p. 77.

the national wealth will be augmented, and Government will receive into the exchequer, without expense of collection, a sum which the Company propose to pay as a tax on their net profits, and which, if they are not too sanguine, will form no contemptible addition to the public revenue. If, on the other hand, the plan should fail, the risk will be confined to those who embarked in the project."

As to the objects to which the new mode of lighting may be applied, it is stated that " one of the most obvious applications would be to light up the streets. By means of pipes laid under the pavement, the gas would be distributed in all directions from the central furnace, and lateral branches going off at proper distances would feed the lamps with a constant supply. Such is the purity of the gas, that the pipes through which it flows, whether they be of lead, tin or pottery, contract no soil by use.[1] The original expense of laying them, together with the cost of the furnace, is all that would ever be required ; the preparation of gas being itself a lucrative process, that would pay all its expenses and interest on capital, and leave a large surplus of profit. Indeed, this application of the gas is no longer problematical, since one side of Pall Mall is lighted up as an experiment, and the gas is abundantly and regularly supplied."

The pamphlet concludes with the observation that " upon the whole, when we reflect that the object of the proposed Company is to open a source of national wealth of which nothing can deprive us, to *create*, we might almost say, new articles of value, and, at a crisis like the present, to render us independent of foreign powers for a necessary of life, its friends cannot be thought guilty of great presumption if they look forward to the countenance and protection of a British Parliament."

Although from the foregoing it appears to have been the intention of the Trustees to obtain the sanction of Parliament to the formation of a Company for the purpose of carrying out their project, their first step was to memorialize the Privy Council for a Charter of Incorporation. This is apparent from a report which was submitted by them to the subscribers to the Fund for assisting Winsor in his experiments, at a meeting held at the Crown and Anchor Tavern in the Strand, on the 26th May, 1808. This report goes fully into the circumstances of the formation of the Fund, the powers invested in the Trustees, and the various steps taken by the latter to carry out the wishes of the subscribers. It appears from it that the Trustees were empowered to incur expenditure to the extent of twenty thousand pounds for the purposes of the undertaking ; and that, " finding the public mind much agitated by claims which had been excited for the safety of individuals whose lives and properties were stated to be in danger from the apparatus and tubes necessary for making and conducting Mr. Winsor's hydro-carbonic gas for lights being liable to explosion from the mischievous application of a mixture of other gases ;" also that " his gas was mephitic and destructive to animal life," they instituted a series of such investigations as were best calculated either to establish or refute the foundation of such alarms, with the result " that their experiments have established beyond doubt, both the safety of Mr. Winsor's apparatus for making, and of his tubes for conducting, the hydro-carbonic gas for lights ; and the concurring testimony of medical men will prove that instead of being destructive to animal life, gas combined with atmospheric air is, in pulmonary cases, known to be (and therefore often prescribed as) both a safe and efficacious remedy." This is an assertion of Winsor reiterated. The next paragraph is a testimony to Winsor's good faith. " Your Trustees," it says, " in the course of their experiments, and they were experiments made with the greatest care and diligence (experiments during which their attention was directed to the most minute and scrupulous account of weight and measure, time, quantity, and, in truth, every means that could prove the result to be produced from coal carbonated in Mr. Winsor's stove), had the satisfaction to find that the truth of his statements was verified and established. That it produced all the quantities he in his publications had stated, of coke, of oil-tar, of ammoniacal liquor, and of inflammable gas. And the Trustees, too, had the satisfaction to find, that beyond the common properties attributed to his coke, and to his ammoniacal liquor ; that the first was found capable of assisting in the making of gunpowder ; and that the latter was rendered more valuable than was originally imagined, by proving upon experiment to be an excellent mordant in dyeing."

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[1] " Mr. W.'s tubes have been in daily use for eighteen months, and are as clean as when they were put up."

The report relates the steps that were taken by the Committee to bring the subject under the notice of the Chancellor of the Exchequer, to whom it was presumed to appeal in an especial manner, because of the public revenue which it was confidently anticipated would be derived from the new process. They had reason to believe that the details of the latter created much attention, " since the Chancellor of the Exchequer did them the honour to advise its reference to his Majesty's Most Honourable Privy Council." Accordingly, a memorial was drawn up and submitted to the Privy Council, praying for the grant of a Royal Charter. A copy of this memorial is given as an appendix. It was referred by the Privy Council to the Attorney and Solicitor-General, who reported " that such charter could not properly be effected from his Majesty ; and that an Act of Parliament would be required to carry it into execution."

Having regard, however, to the then advanced period of the session, the Committee decided that it would be inadvisable to " burden your funds with the charge necessarily consequent upon an application to Parliament, without the prospect of success." As a first step, therefore, they, through their Chairman, Mr. Grant, endeavoured to ascertain whether the Chancellor of the Exchequer " was disposed, upon his present view of the merits of their case, to countenance their proceeding in the prosecution of the wishes of their constituents, in the soliciting of the required Act of Parliament." The reply received from the Chancellor of the Exchequer (Mr. Perceval) was not encouraging. He stated " that he was not himself sufficiently convinced of the public utility or importance of a Light and Heat Company, to induce him to give his parliamentary support to the establishment of such an institution, particularly in the advanced state of the present session." To a further application, desiring to be informed of the nature of Mr. Perceval's doubts with regard to the public utility and importance of their proposed institution, no answer was received by the Committee. They accordingly decided to call the subscribers together and take their instructions as to further action. After stating that the funds at their disposal from the sale of exchequer bills had amounted to £6178, 5s. 2d., of which £5175 had been expended, leaving a balance in cash of £1003, 4s. 9d., besides nine exchequer bills, the value of which was left to be reported to the meeting, the Trustees intimate their desire to leave the question of applying to Parliament to the consideration and judgment of the meeting. " For themselves, they do not hesitate to say that experience has taught them, and it is but justice to Mr. Winsor to repeat, that his plan is both safe and practicable. But it is for you to decide whether the public shall, by an application to Parliament, have constitutionally before them, a view of those advantages which are to be derived to its expenditure as individuals, and to the State, as a revenue. That the public may be enabled to understand, that whilst articles of necessity will be cheapened to its use, the nation will acquire a more than corresponding value, in the diminution of supplies, now wanted from foreign countries—in the consequent independence it will create to her in the relations of foreign commerce—in the means of taxation both upon the article used, and the income to be derived from it, and from the necessary and consequent balance it will give to her trade, by the increase of exports which without this discovery could neither be articles for home consumption, nor of foreign traffic."

In concluding the report, the Trustees " deem it part of their indispensable duty to advert to the conduct and circumstances of Mr. Winsor. From the inexperience of the persons whom he has had in his employ, the apprehension which he naturally felt, lest his secret should be prematurely disclosed, the frequent fluctuations of his hopes and fears, and the anxieties occasioned by his pecuniary embarrassments, his personal fatigues and mental sufferings for a long time past, have perhaps been seldom exceeded. It is, however, due to him, in strict justice, to declare, that making due allowance for this accumulated pressure upon an ardent and irritable mind, the Trustees have had great reason to be satisfied with his conduct in the course of the experiments, which have been made under their directions ; and that, in all his pecuniary transactions, he has acted (as far as your Trustees possess the means of forming a judgment upon them) with strict integrity. Your Trustees deem it right further to declare, that the failure of their endeavours to effect the Establishment of a Light and Heat Company, under a legal constitution, is not to be attributed to any fault, or failure, on the part of Mr. Winsor. Under these circumstances, your Trustees feel great concern in observing that the debts which he had incurred in the prosecution of his experiments, amounted so early as the beginning of 1806 to £4000. That they have since been increased by the further sum of £2000, amounting together to £6000. Although your Trustees do not conceive it to be consistent with their duties, as defined by the deed of trust, to propose to the subscribers to relieve Mr. Winsor from the pressure of this debt; yet they trust they may venture to submit his case, upon the ground above stated, to the humane and liberal consideration of the subscribers; the more especially when it is recollected that his engagements with the public have prevented his deriving any personal advantage from his discoveries, even to the present moment." To what extent, if any, this appeal or representation was responded to does not appear; but it will be recollected that in the scheme for the establishment of a public company to work the new process,[1] Winsor was to have 1 per cent. of the emoluments of the Company in part consideration of the great expense he had incurred "during almost five years' constant trials." Apparently at this meeting the subscribers decided on making an application to Parliament, and this gave rise in the ensuing session to the first momentous contest which is upon record in connection with gas supply. From the nature and extent of the opposition to this application, it might almost be supposed that it involved the granting of a monopoly in the new mode of lighting. This, however, was not the case; but Murdoch and his friends could hardly be expected to view with indifference proceedings which, if successful, might have established Winsor's claim to priority. Neither Boulton & Watt nor Murdoch had any patent rights in connection with the invention of gas lighting; but they, as has been seen, were at this very time engaged in supplying gas plant, and fitting up installations of gas lighting; Clegg, Pemberton, and others being similarly occupied. Winsor, however, persistently refused to recognize what was being done elsewhere, believing himself to be the sole possessor of the secret of the art of gas lighting; as he was, in point of fact, the only patentee in connection with it. "Pray," he had said the year before, in answer to Nicholson's criticisms, "has Messrs. Diller's, Murdock's, or Nicholson's object proved the extent or benefit of the National Light and Heat Company?" . . . "or will Messrs. Diller, Murdock, and Nicholson swear and prove, that they invented, used, and exercised an apparatus that would save all the valuable component parts of coal and other fuel-apparatus that could be applied to the general good of the country?—in fine, an apparatus, such as stood the test of three trials by three respectable gentlemen, near three years ago, the details of which I have published?" With this belief in the novelty and utility of his methods and proposals, Winsor had fully impressed his associates and supporters; as witness their abortive application for an exclusive Charter. It is not, therefore, surprising that this application to Parliament should have been regarded by Murdoch and his friends as, in effect, a direct challenge to them. They thought that the granting of the privileges asked for might not only confirm Winsor in his pretensions as the discoverer and inventor of gas lighting in succession to Lebon, but—what was perhaps of more material consequence—might seriously jeopardize the business in gas apparatus which they had been building up. Accordingly, a petition was lodged against the Bill by Murdoch, who was represented, when it came before the Committee of the House of Commons (in which House it originated) by no less a personage than Mr. (afterwards Lord) Brougham. Counsel for the promoters were Messrs. Warren and Harrison, and the Chairman of the Committee was Sir James Hall. The Committee met for the first time on the 5th May, 1809, and the inquiry lasted for nearly a fortnight. The first witness called for the promoters was Frederick Accum, a chemist, carrying on business in Compton Street, Soho, who was afterwards the author of Accum's *Practical Treatise on Gas Light*, and also one of the first Directors of the Chartered Gas Light & Coke Company. Accum had previously been associated with Winsor's Committee in carrying out the experiments referred to by them in their report to the subscribers. He described to the Committee the process of destructive distillation of coal, and proceeded to claim for the stove employed by Winsor, the production of coke " superior to that kind of coke which I have hitherto been able to procure in the market." This superiority was stated to be as three to two, since " to evaporate a like quantity of water, it required two of coke to three of coal, that is, three bushels of coal to evaporate a given quantity of water, whereas two bushels of coke are only required." For smelting ores the advantage of using Winsor's coke was alleged to be equally apparent. For household purposes this product was for certain reasons to be preferred to coal, provided it " has not been charred too much, or has not been exposed to too intense a heat." It was further stated that two descriptions of coke, one nearer the fire, and the other further from the action of the fire, are produced in the ordinary operation of decomposing a quantity of coal for producing gas-light ; one being better for the founder and the other for private use. Asked as to the relative duration of a fire made with coke and with coal, the witness said, " I found in the ordinary way of my housekeeping, when I applied it, that where I light a fire with common coal, it lasted from eight o'clock in the morning till twelve. If the grate were filled with coke, the fire lasted till six in the evening, no attention being paid to the coke, whereas a considerable attention was paid to keeping up a proper combustion of coal." An equal quantity was used in both cases—" as much as could be heaped conveniently in the ordinary way of housekeeping." Again, " In Mr. Winsor's coke, experience has taught me that there is neither sulphur nor any other matter which I detected in other coke in considerable abundance." Towards the end of a lengthy examination on this part of the promoter's case, Accum was asked by Counsel, " Do you then, as a practical man, ascribe the preference to Mr. Winsor's coke to the mode in which it is produced, and not to the intrinsic quality of the coal from which it is made ? (*A.*) In doing this

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[1] P. 101.

I must disclose the process of Mr. Winsor, and I beg leave to be informed if I am obliged so to do.

" (*Q*.) I do not mean to ask that, but without disclosing it, do you consider the preference as owing to the mode of producing it ? (*A*.) I could never produce coke so good as Mr. Winsor's.

" (*Q*.) You consider the preference to arise from the mode ? (*A*.) Probably from the mode of doing it."

This comparison of Accum's was with the method then in vogue of coking in the open air. Asked how Winsor's method compared as to results with Lord Dundonald's method of making coke in close vessels, Accum replied, " I am not thoroughly acquainted with Lord Dundonald's process. It is difficult for me to ascertain, but there is perhaps no material difference between the two." This testimony was scarcely good enough for the learned Counsel, who pressed the witness to give a probable reason for a difference between the two methods, and received in reply, " If I am permitted to disclose the process of Mr. Winsor I can, but I cannot otherwise. I am acquainted with Mr. Murdock's mode of producing gas as it is before the public, and conceive that Mr. Winsor's is greatly and generally superior." Not yet satisfied, Counsel asked, " Would not permitting the gaseous matter to escape produce an effect upon the manufacture of coke, so as to make it inferior to that produced by Mr. Winsor ? (*A*.) It certainly might.

" (*Q*.) That is from the admission of air ? (*A*.) And from other circumstances that might be stated." Subsequently, however, Accum admitted to the Committee that he thought it could " make no material difference with regard to the coke either collecting them (the gaseous products) or distributing them."

Other witnesses were called in support of Accum's statements as to the superiority of Winsor's coke, one of them being a foreman " in the foundry line," who said, that if he owned the business in which he was engaged, he would give more money for a bushel of Winsor's coke than for a bushel of that provided by his master.

In continuation of his examination, Accum produced samples of carbonate and muriate of ammonia, caustic ammonia and sulphur, all made from ammoniacal liquor obtained from Winsor. He was examined at considerable length as to the value of these and other residual products—namely, tar, " asphaltum," and essential oil. The latter he had applied as a substitute for oil of turpentine in painting, and for varnishing ; and the " asphaltum " was declared by him and other witnesses to be superior to " that usually imported." The latter was stated to have risen in value, owing " to the situation on the Continent," from about 50s. per cwt. to 1s. 6d. to 2s. per lb. Reference was again made to Lord Dundonald's method, the Committee desiring to know whether " the results as to yield of pitch, tar, and ammoniacal liquor differed in any respect in Mr. Winsor's process from Lord Dundonald's." The answer of the witness was, " If I mistake not, Lord Dundonald only states tar, but does not mention essential oil." A Mr. William Bryan stated that he had made use of ammoniacal liquor in dyeing. "By making use of metallic mordant, I have been enabled to make a number of neat shades of drab, from the silver grey to the brown, which will stand washing and answer the purpose well, on cotton, independent of any colouring matter than what came out of the ammonia." He produced samples of wool and silk dyed by means of ammoniacal liquor. In answer to the Committee, he stated that he had never used the ammoniacal liquor without a metallic mordant to produce a colour. Reference was made by another witness, Mr. William Cox, to the use of ammonia for agricultural purposes. He stated that he distilled coal in 1796, and found that it yielded tar and ammoniacal liquor —"as to the gas light, I did not pay any attention to that, but let it fly off."

With regard to the practicability of conveying the gas through pipes, Accum expressed the opinion that it could be so conveyed, "like any other fluid, from place to place." . . . "With respect to the elasticity of the gas, we know that it has flowed for miles, as Mr. Murdock has informed the public, in a circuitous route, and therefore we have reason to suppose it would flow to a greater distance. It flows as all other fluids do, though assisted by the rarefication it undergoes; by its elasticity it will flow upwards, which other liquids cannot do. . . . There is not any danger of this gas bursting the pipe in which it is contained, in the manner I have seen it generated by Mr. Winsor, and conducted through the pipes constructed by him. If more gas is liberated than could escape through an opening, there would be danger of bursting. If there was no reservoir the gas could not accumulate. But there is no reservoir in Mr. Winsor's plan. The pipes contain the gas without a reservoir." This absence of gasholders was unquestionably a weak part of the scheme, since even at that early period they had been found by Murdoch and others to be indispensable. The crudity of Winsor's ideas in this respect had been previously made apparent in his *Plain Questions and Answers, &c.*, in which it is stated that "if we turn off a million of lights in London at once, the gas will return to the trying pipes in the parish furnaces, and assist in the carbonizing of coal; but it will be much better employed to flow in the street lamps, which will give ten times more light than at present, and prevent the nightly depredations in the Metropolis."

Beyond the above statement of Accum's, the engineering evidence in support of the scheme appears to have been confined to that of Mr. Joseph Kaye, a surveyor, who surveyed the parish of St. James's for the promoters.[1] This witness estimated that the length of mains required would be between 13 and 14 miles; the length of pipes already laid by Winsor being about 1700 feet. There were to be six stations within the parish, each station to be within a distance of 2000 feet from the station next to it, the cost of fitting these up would be about £500 each; the total cost for the parish being £24,000. This included cast-iron pipes 3 inches in diameter at 3s. per foot, or wrought-iron pipes "at much less expense." Subsequently the details of this estimate were handed to the Committee, of which the following is a copy:

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[1] According to an extract from the return made under the Population Act, which was handed in by Mr. Kaye, the number of inhabited houses in the districts proposed to be supplied by the Company was at that time as follows:

In St. James's, 3430.
In the whole of Westminster, 18,231.
In the whole of the cities of London and Westminster, 121,229.

"A Calculation of the Expenses attendant upon Lighting the Parish of St. James, Westminster.

Cost of erecting 6 Stoves at each station, being 6 stations at £30 per stove . . .	£1,080	0	0
Expenses of erecting and adapting Buildings at the several stations at £500 each station .	3,000	0	0
Digging and filling in Ground for laying down the Tubes	867	5	0
Taking up and relaying the Carriage Pavement, and making good the same . .	1,962	0	0
Do. to the Foot Pavement	1,050	0	0
65,500 feet of Iron Tube for the main service at 3s. per foot . . .	9,825	0	0
Plugs, Stop Cocks, &c. . . .	500	0	0
Lamps and Burners, Service Pipes, Lamp Irons, and Works	4,000	0	0
Contingencies, making good Damages, and Expenses, at £10 per cent..	2,228	8	6
Labour at £3, 3s. per station per week . .	982	16	0
£25 per cent. for Wear and Tear on Stoves .	270	0	0
£2½ per cent. on Buildings .	75	0	0
£2½ per cent. on Tubes . . .	245	12	0
£2½ per cent. on Posts and Burners .	100	0	0
Rent of 6 Stations, at £60 per annum .	360	0	0
	£26,546	2	0

"Seven hundred and Thirty Chaldrons of Coals, being two Chaldrons per night, for the production of Gas, necessary to light the Parish of St. James with 800 Lamps,[1] with three Cock's-spur Burners upon the Pean, and with the quantity of Light in the Cock's-spur Lamp in Pall Mall."

With reference to the extent and value of the light obtained by distilling coal by Winsor's method, the witness stated that he had compared the light produced by a flame of gas with the light produced by an equal flame of a tallow candle. He brought the flame to an equal size by constructing "an apparatus with perforations which permitted the gas to flow through it in such quantities only that when set on fire the flame thus produced measured, as near as could possibly be ascertained, the same size as that afforded by another luminous body, a candle I made use of, which was given as a standard. That was the plan I adopted, and the same experiment I made with Mr. Winsor's apparatus." Applying to these two flames of equal size, Count Rumford's method of measuring the intensity of light by its shadow, Accum found their comparative effect to be nearly as three to one, "provided the combustion of the gas is properly effected." That is to say, the gas flame gave three times as much light as the flame of a tallow candle, according to which "three bushels of coal afford a quantity of light which is equal to one thousand four hundred and seventy candles at twelve to the pound, these candles burning for four hours." In proof of this, the witness stated that he was present when the process for producing the gas from three bushels of coal was carried into execution. This experiment lasted for twenty-four hours, during eight of which he was actually present; other persons being present the remainder of the time, taking note of the "changes which might take place in the different flames." From their reports the quantity of light was calculated, with the result given above. "There are," said Accum, "no sparks from these flames; . . . to let the gas out, the burners have simple holes, and will not be affected much by the wind, so as to produce extinction, and the rain may assuredly be guarded against." Again, the colour of this light "is a vivid white; a brilliant light. It is the light of the Argand light," and might be made to burn with equal splendour. He stated also, that the lamps burning in Pall Mall were the cockspur lamps, having three points or flames, each flame being "at least equal in intensity to eighteen parish lamps, comparing them as I have met with them, the size of the parish lamp being about that of a small pea, so that the whole three would give fifty-four times as much light, the flames being at least four inches long in Pall Mall; you may make that flame longer or shorter as you please, by turning a valve; the flame may be increased or diminished, by admitting more or less of the gas, by turning a stopper; it is contained in the pipe, just as water or beer is in a barrel, and by turning the cock you let it out."

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[1] These were to be placed about 70 feet apart, on alternate sides of the streets, where these were narrow; the existing lamps being from 30 to 40 feet apart.

On this part of his evidence the witness was subjected to a long and severe cross-examination by Mr. Brougham, the object being to discredit his competency as an expert, and, by inference, his estimate of the amount of light produced by the process. Being pressed as to the means he employed to measure the gas flame, he spoke vaguely of the photometer of Mr. Leslie and Count Rumford, and instruments (which he afterwards corrected to "an opportunity") of his own invention; subsequently stating that he "viewed the flame through panes of glass; I interposed the luminous ray of the candle of which I wished to ascertain the flame, and reflected the shadow of the flame upon a piece of paper against the wall; I delineated the flame, and then I interposed the same pane between the gas-light, and threw the image of that upon the sheet of paper, and of course I obtained two images of the flames ; this being done, I measured them by the common geometrical means." His estimate that one gas light of the size of the light of a tallow candle was equal to the light given by six parish lamps, was stated to depend upon the measure of the bulk of the light, and upon its intensity. On being asked in what way he measured the bulk of the light, he replied that, " from what has passed before this Committee yesterday, concerning the inquiry that has been made to estimate my practical skill with regard to the evidence I am called upon to give, I beg leave to be informed by the Chairman whether I have a right to answer this question without a fee ; I mean to say, whether I am obliged to inform the learned Counsel of the practical proceedings of my profession, which now form a part of my livelihood ? " Further questioned as to the way in which he measured the flames, he said that, " it is a part of my business to be paid for giving information to those who are tormented with the desire of gaining knowledge." On being reminded that he had given information the previous day without a fee, the witness admitted that this was so, " but it was scanty, and the other shall be paid for." This show of reticence evidently served the purpose of the cross-examination ; especially as, in reply to the Committee, Accum expressed the opinion that a flame 1 inch in diameter and 2 inches long, was only double the size of a flame half an inch in diameter and 1 inch long. When pressed as to this, he said he did not calculate the size of the flames " from arithmetical means, but from the result of the actual admeasurement of the light ; " that is to say, " from the intensity of the shadow cast by an opaque body, when it is illuminated by another light." As to how such measurement was performed, he again declined to state ; but at the same time explained, by means of a quotation from himself, the method of measurement by equal shadows, according to which the quantity of light emitted by each of two bodies " will be exactly as the square of the distance of the burning body from the white or illuminated surface."

With regard to the statement that gas burnt from three bushels of coal gave a light equal to that of fourteen hundred and seventy tallow candles burning for four hours, and costing, as pointed out by the Committee, £6, 1s. 6d., it was elicited that for the purposes of this comparison one tallow candle was used, this being completely consumed in the four hours, which was the time it took to burn the whole of the gas, which was not measured.

On the 12th May the opposition commenced their case, the first witness called on behalf of Murdoch being Mr. George Lee, of the firm of Phillips & Lee, cotton spinners, of Manchester, for whom Murdoch constructed the first apparatus for lighting by means of gas. This was about the year 1804, in Lee's own house,[1] where it was applied in order to determine whether it was applicable to the cotton mills. In 1805, an order was given to Messrs. Boulton & Watt to light the latter, and the apparatus for the purpose was put up in 1806, and completed in 1807. It perfectly answered the purpose.

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[1] Situated in Chapel Street, Salford.

The method by which this mode of lighting was compared with oil or candles was, as described by this witness, not unlike that employed by Accum; a quantity of gas being burnt "which corresponded with the flame of a candle." No measurements were, however, taken of either flames or shadows, the opacity of the latter being held to determine the relative intensities of the lights. The gas, also, was in this case measured by means of a "gasometer, a vessel holding gas, suspended in water." "The quantity of gas consumed in a given time, producing the same light with the tallow, was measured with the gasometer and weighed with the candles, by which means we obtained a comparison of the bulk of the gas and the weight of the tallow. The result of that comparison was that half a cubic foot of gas corresponded with a candle of six in the pound, burning for an hour. These experiments were made under my direction and inspection.

"One hundredweight of coal produced three hundred and fifty cubic feet of gas; from that experiment, six pounds of coal will be found as equal to one pound of tallow, which coal yields illuminating matter equal to one pound of tallow." . . "We have laid out on this apparatus between £5000 and £6000. The total expense of the gas apparatus, I believe, is about £500 a year. The expense of candles, to give the same light, would be about double. Here are the memorandums:

Cost of one hundred and ten tons of cannel coal .	£125	0	0
Do. of forty tons of common do. . . .	20	0	0
	£145	0	0
Deducted value of seventy tons of coke . .	93	0	0
The annual expenditure in coal, after deducting the value of the coke, and without allowing anything for the tar, is therefore	£52	0	0
And the interest of capital, and wear and tear of apparatus	550	0	0
Making the expense of the gas apparatus about £600 per annum."			

No difficulty, it was stated, had been experienced in obtaining the apparatus from Messrs. Boulton & Watt, nor as regards insurance of the premises. "I have seen," said the witness, in reply to Counsel, "the lamps in Pall Mall, and compared their effect with that of my own, but did not see any superiority in those in Pall Mall." Subsequently he stated that he considered "ours the cleanest and steadiest." "There is not any disagreeable smell produced by the gas; nothing objectionable at all. The light is clear and agreeable to the eye, far superior to any other light, and I have every reason to be satisfied with it."

It was further elicited in cross-examination, that "the total quantity of light used during the hours of burning was ascertained by a comparison of shadows to be about equal to the light which two thousand five hundred mould candles of six to the pound would give, each of the candles, with which the comparison was made, consuming at the rate of one hundred and seventy-five grains of tallow per hour." So that "half a cubic foot of gas is equal to the consumption of one hundred and seventy-five grains of tallow." "The light in our manufactory is equal to that of two thousand five hundred candles of six in the pound; the number of burners employed in all the buildings amounting to two hundred and seventy-one Argand Lamps and six hundred and thirty-three cockspurs." . . . "The kind of coal we make use of is the cannel coal; I weighed the tallow and measured the gas. . . . The health of our manufacturers is not in the least affected by the use of gas, or I would not have adopted it; I used it in my own house first. There is an additional ventilation, so as to enable the men to bear the heat which is produced. I have not seen the least alteration in the health of our workmen; for had I seen it, it would have been a fatal objection to it. And the same with regard to the use of it in my own family."

The witness further stated that no particular account had been taken of the value of the tar produced by the process, but about £100 worth had been sold in two years. Also that the street in which he lived was lighted up as far as his house—a distance of about 300 feet. Allowing for turning, the gas had to travel about 1000 feet, and the whole length of pipes in the manufactory was between two and three miles. Six furnaces placed side by side furnished the gas, the pipes conveying it being 5-inch diameter, tapering at the extreme end to ½ inch in diameter. The gasholders were cubes of 10 feet, so as to have a content of 1000 cubic feet, made of sheet-iron, painted. They were not quite in equilibrium, the difference being equal to a column of water half an inch high. It was explained that gas is received into the gasholder for the purpose of "taking away any superfluous quantity of gas which would be formed, that is not consumed, and to enable the manufacture of the gas to go on at the time it is not burning." The utility of this apparatus was also referred to by James Watt, junior, who in the course of his evidence stated that "there is not any danger to which the gasometer is exposed; it is protected from the action of the outer air, the lower part of it is immersed in water, and consequently protected, and the upper part, which is not immersed in water, is made of sheet-iron, painted, and therefore no atmospheric air can enter; it is only filled with inflammable air, which cannot burn without the access of the atmospheric air, nor without the access of oxygen. I conceive it to be perfectly safe, and more, to be economical. Its advantages are—supposing a building to be lighted up during the usual hours of working in the evening and morning, if the gas were derived directly from the retort, a considerable interval must occur when the retorts were not worked during that period; either the fire must be continued in the retort at a considerable expense of fuel, or if the fire is suffered to go out, it cannot be relighted but at a considerable expense of fuel; for not only the heat must be given to the fireplace, but also to the coal within the retort; whereas if a gasholder is used (for the word gasometer has been employed instead of that of gasholder, improperly), the retorts may be kept constantly in action, and by that means no heat is lost, because the gasholder accumulates during the day as much gas as in addition to the produce of the retort in the night in the working hours will supply the demand of the manufactory. By that means the retort is never cool."

On re-examination, Lee was asked, "Do you mean to say that about 6 lbs. of coal by the gas process give as much light as 1 lb. tallow?" He replied, "I do, and I will explain the experiment by which it is proved. I will explain first the apparatus, which is the photometer; the measure of the light itself; the darkness of the shadow cast upon the wall by a cylinder interposed between the candle and the wall, measures the intensity of the light; consequently, if a candle and a gas burner adjusted by a stop-cock produce the same darkness of shadow at the same distance from the wall, the intensity of light is the same, and a uniform degree of light from the gas is produced by opening or shutting the cock if more or less is required, and the candle is carefully snuffed so as to produce the greatest and most regular quantity of light from it. The size of the flame of course becomes unnecessary in this consideration, and will vary with the quality of the gas. As the quality of the gas is subject to some variations, the experimental gasometer was supplied from the mixed production of several retorts, and the result is the average of a vast number of experiments taken during the whole winter. The gasometer which was used for the experiment contains a measured quantity of gas, and the communication between it and the retort, and any other supply was interrupted, during the experiment, by a cock. The gasometer descends in the water as the gas is exhausted, and the bulk of the gas used is ascertained by the area of the gasometer, and the depth which it sinks in the water, therefore the bulk of the gas consumed in a given time is measured by the gasometer, and the quantity of tallow used is determined by weighing the candle before and after the experiment. Results. The light produced by a candle of six in the pound requires 175 grains of tallow in an hour, 7000 grains are equal to a pound avoirdupois, and consequently 1 lb. of candles of six in the pound, burning one at a time in succession, would last $\frac{7000}{175}=40$ hours. One-half of a cubic foot of gas expended per hour produces the same quantity of light, consequently one-half multiplied by 40 hours equals 20 feet of gas expended in 40 hours, consequently equal to 1 lb. of candles. . . . One hundred and twelve pounds of coal produced nearly three hundred and fifty cubic feet of gas; and three hundred and fifty cubic feet of gas are equal to $\frac{350}{20}$, which last is equivalent to one pound of tallow, and makes one hundred and twelve pounds of coal, equal to $\frac{350}{20}=17\frac{1}{2}$ lbs. of tallow; consequently 112 lbs. of coal divided by $17\frac{1}{2}$ lbs. of tallow, is six and four-tenths lbs. of coal, for one pound of tallow." Cannel coal costing $13\frac{1}{2}$d. per cwt. was used in this experiment.

Mr. (afterwards Sir) Humphrey Davy was called to prove that the coke made by Winsor's process was " not superior to the common coke." A Mr. Lawson confirmed this evidence by particulars of an experiment made by him to ascertain the amount of water evaporated by an equal quantity of each kind of coke. Other witnesses testified to the utility of the gas-lighting arrangements supplied by Boulton & Watt, and as to the practical identity of the products derived from Murdoch's and Winsor's processes, the case for the opposition being that the superiority claimed for Winsor's process did not exist. James Watt, junior, of the firm of Boulton & Watt, then related the history of his firm's connection with Murdoch's invention, as given in a previous chapter. He further informed the Committee of the great development that had taken place in this branch of his firm's business, and expressed his fear that the establishment of an incorporated Company as contemplated would seriously injure his firm, and probably oblige them to abandon the manufacture of gas-lighting apparatus. This aspect of the case had already been opened up by Lee, who expressed the opinion that all that was necessary for the development of gas lighting could be done with private capital, and also that a fair competition could not exist if a corporation were to be established, urging by way of illustration that " if a corporate body was suddenly to be performed in my own business, and so much additional capital suddenly brought in under circumstances unfavourable to me, my trade would be injured by it." He was questioned as to this view of the case by a member of the Committee—Sir Robert Peele—whose final question " Would not the public be better supplied by a corporate body ? " received for answer, " I think that the public is always injured when competition is diminished." Watt took the same ground. After stating that he found no more difficulty in meeting orders in that department of his trade than in any other, he said that he had not foreseen any circumstances that could occur to impede his operations until he heard of the probable establishment of the Incorporated Gas Light & Coke Company. This, he was apprehensive, would interfere with them because a Chartered Company of individuals, who are not liable to the risks of private traders, would place his firm in a comparatively disadvantageous position. " What," he was asked, " would be the consequence if this Company were established and so chartered ? " to which he replied, " The consequence would be that certainly (whatever might become of the work already erected) further experiments would be out of the question, and I should get out of the business as soon as I could." Watt afterwards qualified this by saying that his retirement from the business would probably result from the establishment of the Company. He was examined at considerable length and with great acumen by the Committee as to the possibility of the gas-lighting scheme being carried on without an Incorporated Company, and the advantages of such over private enterprise. " Do you think it possible," he was asked, " that such a scheme, as now projected, for lighting this metropolis, could be carried on without a Chartered Corporation ? " " I have no doubt," was the reply, " if any advantage is to result from it, that it might. I beg leave to state my opinion a little more fully on that head. I conceive that the most beneficial application of the gas light is in those situations where the light is most concentrated, and that where it is most diffused the advantage is the least. I therefore conceive it natural that it will in the first instance be introduced into cotton mills, and other manufactures where a great quantity of light is wanted in a small space ; and when the advantage is fully felt and understood, it will gradually find its way into other public uses where the advantage is certainly less." His contention was that if only a moderate capital—say, £100,000—were needed to produce a considerable effect in lighting the Metropolis, this could be effected without a corporation ; while as to the employment of a very considerable capital, he was unable to say how far the scheme held out any inducement to " a company of adventurers who should be subject, like other individuals, to the bankrupt laws." Also that the new discoveries had already been carried into practice with advantage to the public without a Charter, and that the apparatus would go on improving in proportion as it came to be more used. He was, however, quite unable to say in how many years individuals were likely to undertake the lighting of the Metropolis. With regard to capital requirements, " Do you conceive," he was asked, " that a capital of £300,000 would be deemed an excessive capital to be engaged in trade in the town of Birmingham? (*A*.) Very excessive; I believe the whole amount of capital in the manufacturing trade of Birmingham does not exceed £500,000, or from that to a million ; I am speaking of the town of Birmingham itself . . . I allude to the regular hardware manufactures of Birmingham." Later, Watt was asked, " Do you not think that if this plan of extracting all these properties from coal goes on, it does open a vast and extensive field for the employment of capital ? (*A*.) As an investment of capital in the apparatus ? (*Q*.) No, generally speaking ? (*A*.) Not that I am aware of, independent of the execution of this apparatus for producing the gas. (*Q*.) " Does not the prospect of the employment of capital in the execution of the machinery open a wide field for the employment of capital ? (*A*.) It does. (*Q*.) "Do you think that a limited capital say of £200,000 or £300,000 granted to a Chartered Company, would be injurious to the general undertaking of the work, if it opened such a field for the employment of capital ? (*A*.) I conceive it would be injurious to individuals and consequently injurious to the public." Finally, the Committee put it to Watt, " whether there is anything which you can point out in any part of the Bill which prays for an exclusive privilege, or which shuts out in any respect any competition ; supposing one individual or three individuals, or this Company, can carry it on to greater advantage with a capital from £100,000 to £500,000, is there anything in this Bill which shuts them out from offering themselves to such service ? (*A*.) There is nothing in the Bill expressive of a direct monopoly, but it would be the effect of the Bill though not expressed."

These extracts are sufficient to show the comparatively narrow view which influenced the opponents of Winsor's scheme. Their evidence, in so far as it proved the practicability of lighting by means of gas extracted from coal, could not but lend support to that of the promoters, although at the same time it discredited the extravagant anticipations of the latter. It was a confronting of visionary statements with solid facts ; but these could not but reveal the real strength which underlay the case for the Bill, and must, from a strategic point of view, have been invaluable to the promoters of it. Moreover, the opponents entirely failed to grasp the significance and possibilities of the scheme propounded by Winsor. The idea of a public supply of gas lighting was beyond them ; they saw no further than a gradual extension of separate private installations. They took alarm at the prospect of the establishment of an incorporated Company as likely to interfere with their business, and were not appeased by the suggestion that this might open up a wide field for the employment of capital in the provision of the necessary machinery. In this respect their opposition bore fruit, since by the Gas Light & Coke Company's Act, 1810, it was enacted (Clause 28) that the Company " shall not by any Ways or Means, or under any Pretence or Pretences, contract to sell and furnish, or shall sell or furnish any Stove or Pipe, or Pipes, or Apparatus or Machinery of any Description whatever, for the Purpose of conveying, or whereby such Inflammable Air as aforesaid, or any Quantity thereof may be Conveyed into any Dwelling House or Houses, Manufactories, public or private Buildings, for the purpose of lighting the same." The evident intention of this clause was to protect the manufacturers of gas appliances from the possibility of competition with the Incorporated Company. Such intention has continued to pervade gas legislation down to the present day.

During the progress of the Bill through Parliament, Murdoch addressed a letter to a member of Parliament " in vindication of his Character and Claims ; in Reply to a recent publication by the Committee for conducting through Parliament a Bill for incorporating a Gas Light & Coke Company." He writes with considerable warmth, and as smarting under a sense of the injustice done him by the promoters of the Bill in the publication to which he refers. This letter has not been referred to by any writers on the early history of gas lighting, but was reprinted by Mr. Richard B. Prosser in 1892. It runs as follows :

SIR,—Having this moment finished the perusal of a publication, issued by the committee for conducting through Parliament a bill therein depending, for incorporating a certain Gas-Light and Coke Company, I feel myself called upon thus to notice the very unfair and illiberal manner in which I am mentioned throughout that publication ; which, if it had not been avowed as coming from a COMMITTEE of gentlemen, I must have considered as the production of an anonymous calumniator.

I address this letter to you, Sir, as a member of that Parliament through which this Gas-Committee propose to conduct their bill ; but, through which, I venture to promise myself, they will not conduct it; relying, as I do, on the justice of the legislature, and on its wise and sound deliberation.

Time will not allow me to follow any other method than that of pursuing the pamphlet in the order in which I find those remarks that are injurious to me.

I never did pretend to the discovery of the inflammable principle of the gas from coal. In my paper, published in the *Philosophical Transactions* for 1808, I ascribed that discovery to Dr. Clayton so far back as the year 1739; in borrowing from which, this committee have inaccurately referred to a period anterior, as I conjecture, to the doctor's birth.

I willingly admit that the question is, as to the *first application* of the gas, as an *economical substitute* for oils and tallow, in the production of light for public and private purposes. This is what I have claimed, and for which I have been honoured with the Royal Society's gold medal; disgraced, I should rather say, if I have *no* claim to the merit thus imputed to me.

But how has this committee stripped me of my claim? Did the German *Diller*, by his philosophical fire-works at the Lyceum, by "his large lustres of little flames in the centre of the room," exhibited for the amusement of the curious and ignorant, make the application of gas to purposes of public and private *utility*; guarding, as I am informed he did, at the same time, his mode of proceeding, with all the mercenary caution of a juggler? Can the Gas-Committee set this puppet-show entertainment up against my practical application of the gas from coal[1] at the Soho Foundry, and at the Cotton-Mills of Messrs. Phillips & Lee, and Mr. Lee's dwelling-house? I put it to that committee, whether this is a fair and honourable proceeding, or, with what candour they can refer to the pretended economical use of inflammable gas, communicated, as they say, some years after Diller's exhibition in 1788, to the Academie Royale des Sciences, at Paris, without referring to the particular volume or date. Such notice was never heard of by me until this moment, nor have the committee favoured us with the particulars. In their anxiety to ascribe the invention to any source rather than to me, they forget that it is incumbent on them to show that any practical mode of application was pointed out, and the advantage resulting from it demonstrated, prior to the period at which I can prove these points to have been known to me, and communicated to my friends. So far from having given such proof against me, the whole subject was enveloped by Mr. Winsor and his friends in mysterious obscurity, and exaggerated and delusive estimates; and would have still continued in that state, had I not put the public in possession of my discoveries and experience, by the paper above alluded to.[2]

These gentlemen, pursuing the same system of candour, next attempt to throw doubts upon the safety and economy of the method by which I apply the gas ; and they ask whether any man of science will say that it is without evident and serious risk ?

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[1] I never heard till now of Mr. Diller; but from a suggestion given to me, I suspect Diller's gas was not produced from coal, which Mr. Winsor's committee must prove, if they think they can make anything of that very weak point.

[2] *Philosophical Transactions*, part i. 1808.

These questions are best answered by matter of fact ; by three years' safe and profitable experience at one of the greatest cotton-mills in the world ; to say nothing of the many other instances in which it has been used without any accident at all. The committee go on to state that it was not their wish to have made comparisons between their method of lighting and Mr. Murdock's ; and, in pursuance of this wish, as it would seem, they carefully abstain from putting the public in possession of such authenticated documents of the original cost and daily expenditure of their establishment in Pall Mall, as would enable them to draw the comparison themselves. But, probably this secret may sometime or other be imparted to their subscribers, if not to the public.

There will then be a curious *balancing of claims* among themselves ; at present, the Gas-Committee amuse themselves in balancing *my* claims. But I do not like their administration of justice, as I find it does not consist in rendering to every one his own. In page 4, they said of me : " all he did was to add to the length of Mr. Diller's pipes." And, in their balancing of claims, they attribute to me and my connections little more, comparatively, than the *assumed* priority of discovery, while they take from me what I have a very just claim to—viz., " the merit of performing the arduous task of bringing the original hint to practical and extensive perfection." I beg pardon, the word *perfection* I take from the pamphlet, using it only as a quotation from thence.

Without the smallest emotion of envy, I leave to the successor of Mr. Diller and his claim-balancing-committee the whole of their pretensions to PERFECTION, which, in page 9 of their pamphlet, they distinctly assume to themselves, with what decorum or discretion I shall leave others to judge, as well as of their " most undoubted and undisputed regard for *public* advantage." For my part, I think posterity will enjoy this invention, as they now do others, in greater perfection at some distant period from the æra of its commencement ; and, as to the disinterestedness of the committee, it will best be judged of from their professed expectation of gain, which, in one of their publications, is stated at £570 per annum, upon every £5 deposit, even after throwing off first, half, and then 9-10ths of the other half, of the first estimated profits, to guard against the possibility of error ! Does not this necessarily call to our recollection the idea of the South-Sea Bubble ?

Possibly the Gas-Committee may feel some remorse ; perhaps they may not think it sufficient to have expressed their respect for my *talents*. I begin to have some hopes from their morality, finding, as I do, to my great consolation (in page 14), that, if *private right* were invaded by this measure, the authors of it (meaning, of course, themselves) would not have attempted it. If, then, that committee should consider *private character* as a private right, which, according to the universal feelings of mankind, in civilized society, has been ever esteemed the dearest of all rights, they will perhaps endeavour to restore to me what they have attempted to wrong me of.

But, while I claim justice for myself, it is fit that I should do justice to others; to Messrs. Boulton, Watt, & Co. I mean; by the assistance of whose practical and scientific skill and persevering exertions, at whose risk and through whose influence, its successful introduction into public use has been effected; and to Messrs. Phillips and Lee, for their spirited adoption of so great a novelty, and particularly for the singular accuracy of attention bestowed by Mr. Lee, as well as his suggestion of improvements. Had any part of this co-operation and encouragement been wanting, the plan would not have attained its present growth, that growth which resembles the growth of a tree, from its infancy towards its maturity. It would require more time than I can here dedicate to the subject to set forth all the cautious and judicious steps of that progress, which the committee, not very considerately, have stigmatized with the character of *delay*.[1]

It may be proper I should add, that the cotton-mill of Messrs. Phillips & Lee is not the only one that has been lighted up by Gas from Boulton, Watt, & Co.'s manufactory, and, as the Gas-Committee have the public good so much at heart, they will unquestionably receive no small delight in learning that the apparatus is in preparation at Soho, for various other manufactories, and is likely to extend its beneficial influence from thence almost as widely as the *steam-engine* has done. This gratifying intelligence I owe to that committee for their generosity towards me. I would endeavour, if I knew how, to reconcile this undoubted and unquestionable fact with the allegation contained in page 1 of the bill in question, which imports that the Gas-Light and its accompaniments of oil-tar, pitch, ammoniacal liquor, inflammable air, and essential oil, " *cannot* be brought into general use, or the manufactory thereof be made of full advantage to the public, unless a *subscription* should be made for the purpose of carrying on a manufactory and undertaking, for the producing such articles as aforesaid, and the several subscribers thereto be made one *body corporate*, by act of parliament."

But Messrs. Boulton, Watt, & Co. are not a body corporate, nor have they solicited any subscription, nor do I think they are likely to do so, yet I believe the articles above mentioned will be brought, by their means, into general use; and, as to the MANUFACTORY, *it is already established*. This allegation of the bill being entirely without foundation, will, Sir, I trust, be *rejected* by the committee of your house (*in which* ALL *that come are to have* VOICES, *by the votes 1st May instant*); but then, unhappily, the bill will have no leg to stand upon! In which case, my prediction, expressed in the beginning of this Letter, as to the failure of the bill, will be accomplished; towards effecting which desirable purpose, I humbly beg leave, Sir, to request your attendance in your committee, up-stairs, AGAINST THE SAID BILL.

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[1] Let them be enlightened by what the wise Lord Bacon has said upon the subject of *delays*. " Generally 'tis best to commit the beginnings of all great actions to *Argus* with his hundred eyes, and the ends to *Briareus* with his hundred hands; first to watch, and then to speed."—EDITOR.

I have the honour to be,
Sir, &c.
(Signed) WILLIAM MURDOCK.

London, 4th May, 1809.

On the 16th May the Special Committee made their report on the Bill to the House, and on the 2nd June, on a motion that the Bill be now read the third time, an amendment was proposed "To leave out the word 'now,' and at the end of the question to add the words 'upon this day three months.'"

On a division, in which Sir James Hall, the Chairman of the Committee, and Mr. Mellish, who had also acted as Chairman of it, were tellers in favour of the Bill being read a third time, there voted—

For the third reading . .	38
Against ,, . .	52

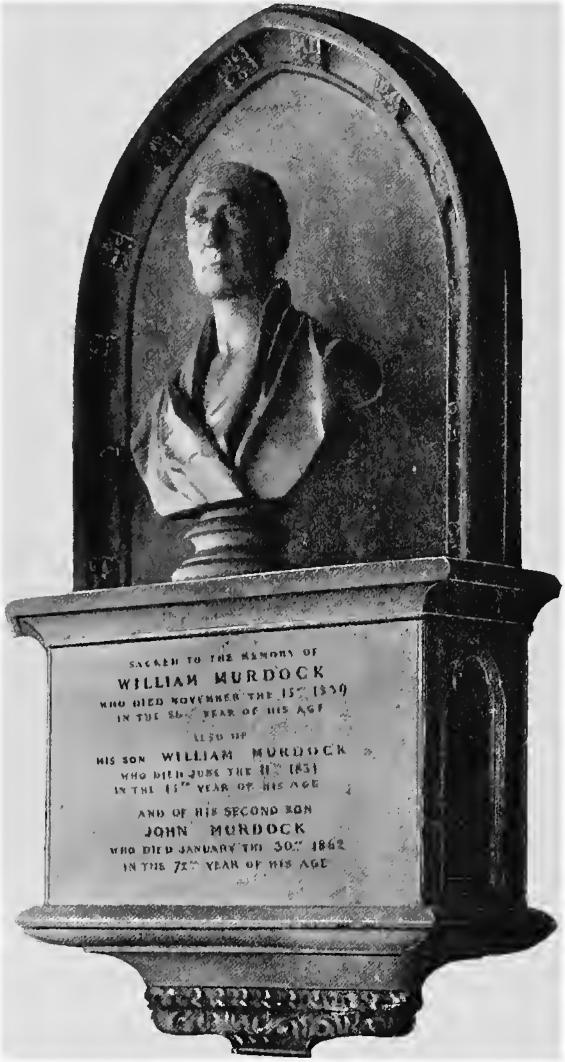
It was thereupon ordered, "That the Bill be read a third time upon this day three months." The Bill was consequently lost, not by the decision of the Committee, but by a vote of the House upon the third reading.

In the following year—namely, 1810—the application was renewed, a smaller amount of capital being asked for; and the Bill passed through both Houses without any petition being presented against it. In the House of Commons, in which House the Bill again originated, the minutes of evidence taken the previous year were referred to the Committee on the Bill; in the House of Lords, Mr. Accum appeared before the Select Committee appointed to consider it; his evidence being substantially a repetition of that which he gave before the Commons' Committee in the previous year. The Bill was, on the 22nd May, refused the third reading, and re-committed, the evidence referred to above being ordered to be printed. Finally, on the 1st June the Bill was read a third time; and it received the Royal Assent on the 9th June.

Two years later—namely, in 1812—a Charter of Incorporation, "to continue for and during the period of twenty-one years," was granted to the Company, which from that time became known for many years as the Chartered Gas Company. The commencement of active operations by the Company, which followed the granting of this Charter, was the starting-point of the system of public gas supply; in the development of which neither Murdoch nor the firm of Boulton & Watt took any part. They did continue for a time to manufacture apparatus for separate installations; but were soon outdistanced by competitors whose attention was probably less divided. Prominent amongst these was "your old servant Clegg," who was destined to leave a mark upon the history of gas lighting scarcely less enduring than Murdoch's own. During the latter part of his life, Murdoch appears to have devoted himself almost exclusively to his mechanical pursuits, in which he was an acknowledged master. In the paper by Mr. Buckle which has been already quoted (Chapter II.), mention is made of many ingenious devices of which Murdoch was the author. Amongst these was a machine for boring stone pipes for water, by which a solid cylindrical core was cut out of the centre of a block of stone; a compressed air engine; also an arrangement for ringing bells, by means of compressed air—the latter being adopted by Sir Walter Scott at Abbotsford. It is also to Murdoch that we are indebted for the cement made of iron borings and sal-ammoniac, which is so much used in gas-works. In 1815 he erected at Leamington a circulating arrangement of his own invention for heating the water for the baths, a system which has since been very extensively adopted for heating buildings. It was while superintending the erection of this apparatus that he met with an accident which endangered his life. A cast-iron plate fell upon him, almost severing the lower part of one of his legs. When he recovered sufficiently to be removed, and being unable to bear the motion of the carriage, the Birmingham Canal Company conveyed him back to Soho in their "excursion" boat.

SYCAMORE HILL HOUSE, MURDOCH'S RESIDENCE AT HANDSWORTH.
(*From "Birmingham Faces and Places."*)

Mr. James Nasmyth, in the account which he gives of a "holiday in the manufacturing districts in the autumn of 1830," mentions that on going through the workshops of the Soho establishment he saw at work the engine with the sun-and-planet piston, an invention of William Murdoch's, and " was especially interested by seeing the action of mechanical tools. There I observed Murdock's admirable system of transmitting power from one central engine to other small *vacuum* engines attached to the individual engines they were set to work. The power was communicated by pipes led from the central air or exhaust pump to small *vacuum* or atmospheric engines devoted to the driving of each separate machine, thus doing away with all shafting and leather belts, the required speed being kept up or modified at pleasure without in any way interfering with the other machines. This *vacuum* method of transmitting power dates from the time of Papin ; but until it received the master touch of Murdock it remained a dead contrivance for more than a century."


SACRED TO THE MEMORY OF
WILLIAM MURDOCK
WHO DIED NOVEMBER THE 15TH 1839
IN THE 85TH YEAR OF HIS AGE
ALSO OF
HIS SON WILLIAM MURDOCK
WHO DIED JUNE THE 11TH 1831
IN THE 15TH YEAR OF HIS AGE
AND OF HIS SECOND SON
JOHN MURDOCK
WHO DIED JANUARY THE 30TH 1862
IN THE 72ND YEAR OF HIS AGE

TABLET IN HANDSWORTH CHURCH, BIRMINGHAM.

With all his ingenuity, however, Murdoch was not always ready to grasp new ideas. Smiles, in his *Men of Invention and Industry*, gives a recollection of him by the late Charles Manby, F.R.S., which illustrates this. Mr. Manby relates that when Murdoch found him "working the first slide rest ever introduced into an engine-building establishment at Horsley, he patted me on the head, and said to my father, ' Neighbour Manby, this is not the way to bring up a good workman—merely turning a handle without any shoulder work.' He evidently did not anticipate any great results from my engineering education. But we all know what machine tools are doing now—and where should we be without them ? "

In his later years Murdoch's faculties experienced gradual decay, and he lived in absolute retirement at Sycamore Hill House, Handsworth, where he died on the 15th November, 1839, aged eighty-five years. He was interred in Handsworth Churchyard, near the remains of Boulton and of Watt ; a bust of him by Chantry being placed within the church to perpetuate his memory.

APPENDIX.

◆

MEMORIAL TO THE PRIVY COUNCIL FROM THE TRUSTEES OF THE WINSOR FUND, 1808.

To the King's Most Excellent Majesty in Council.

May it please your Majesty,

The Humble and Dutiful Memorial of the Committee of the Trustees of a Fund for the purpose of assisting Frederick Albert Winsor in his experiments in Light and Heat;

Sheweth,—

THAT your memorialists crave leave most humbly to submit to your Majesty the result of the investigations, which they, pursuant to their duty, have made with respect to Mr. Winsor's discovery; with a general view of the profit which they humbly conceive may, in the course of a short time, be attained, by the prosecution of this discovery under the direction of a chartered company; and with the considerations which appear to them to recommend this particular mode of management.

2. THAT your Majesty's memorialists are impressed with a deep sense of the novelty, importance, and difficulty of the subject of which they have to treat. That they feel, indeed, that at present it is utterly impossible to form any minute calculations of the whole extent of the advantages which are likely to result from Mr. Winsor's discovery, since they must essentially depend upon the public feeling when the Light and Heat, and other products of his process, shall have been prepared in sufficient quantities to supply the public demand; and there is no existing criticism for their guidance, in forming an estimate of the probable extent of such a demand.

3. THAT your memorialists under this impression will not enter into any detailed calculations, but confining their observations to general views, will humbly endeavour to comprise their introductions of the subject to your Majesty's notice, in as short a compass as the nature of the case will admit.

4. THAT your memorialists, in order to give your Majesty a clear and distinct view of the actual products of Mr. Winsor's process, humbly beg leave

to acquaint your Majesty that an experiment was made by Mr. Winsor on the 3rd and 4th of July last, in the presence of a secret committee appointed for the purpose, consisting of your memorialists' chairman Mr. Grant, Baron Wolff, Mr. Henry, and Mr. Oliphant, occasionally attended in the course of the process by his Grace the Duke of Athol, Dr. Jenner, and Mr. Hargreaves; and that the results of this experiment corroborated, in a most satisfactory manner, the account already given to the public of two former experiments, viz.:—

2 pecks of Newcastle coals weighing 36 lbs., produced of patent coke—

	lb.	oz.
3 pecks weighing	24	2
Of oil tar	3	12
Of ammoniacal liquor	4	6
And of inflammable gas	3	12
Producing in weight (corresponding with the original weight of the coals) a total of	36	0

5. THAT your memorialists having laid before your Majesty an account of the actual products of Mr. Winsor's process, humbly beg leave to insert in this place an estimate of their value founded upon a low scale of calculations, viz.:

3 pecks of coke, a far superior fuel and of double heat, but estimated only as coal at the rate of 60s. per chaldron	£0	1	3
3 lbs. 12 oz. of oil tar of superior quality, but estimated only as common coal tar at 15s. per 112 lbs.	0	0	6
4 lbs. 6 oz. of ammonia estimated at only 1s. per gallon	0	0	6
3 lbs. 12 oz. of hydrocarbon gas, estimated as equal to 40 candles, of 5 lbs. weight, at 10d. per lb.	0	4	2
Total value of products	£0	6	5
Deduct, the cost of 2 pecks of coals at 60s. per chaldron, viz.	0	0	10
There remains an increase in the value of the products gained by the process of	£0	5	7

being at the rate of 670 per cent. From this, however, there will remain to be deducted the expenses of the process, of management, and of the tubes or pipes for the conveyance of the gas to the lamps, &c., intended to be lighted.

6. THAT their present experience does not enable your Majesty's memorialists to calculate these expenses with any tolerable degree of precision. But they humbly represent that they have no doubt that abundant provision will be found for these and all other necessary expenses and considerations in the largely increased value of the new products as above stated.

7. THAT your memorialists having now shown the practicability of gaining

certain products from coal, and their estimated value, wish they were enabled to state in the same distinct and accurate manner to your Majesty, the probable amount of profit to be derived from the disposal of them, but (as your Majesty's memorialists have already intimated) the quantum of profit must necessarily be regulated in a great measure by the extent of the consumption and demand, of which your memorialists are at present not competent to form any tolerable estimate.

8. THAT your memorialists must content themselves therefore with humbly observing to your Majesty that they verily believe, that Mr. Winsor's Gas may be applied with perfect safety and eminent advantage for lighting the public streets, for fixed lights in private families, for lighthouses upon the sea-coast, and for a great variety of other useful purposes; that Mr. Winsor's coke affords double the heat of coal, and is much preferable to coal as fuel, in cleanliness, in security from fire, and in every other respect; and that both his coke and coal-tar are much superior to any other description of coke and coal-tar which have yet been produced.

9. THAT your Majesty's memorialists have reason to believe Mr. Winsor's coke may be applied with great national advantage, in the manufacture of gun-powder. The great superiority in quality and power of the French gun-powder being principally to be attributed to the superior properties of their charcoal, the powers of which your memorialists conceive are at least equalled by certain parts of Mr. Winsor's coke when pulverized. And your memorialists are assured that Mr. Winsor's ammoniacal liquor will be found extremely useful in dyeing and tanning, and for many other purposes.

10. THAT your Majesty's memorialists, upon these general views of the subject, entertain sanguine expectations, that any prejudices, which may now exist, will shortly be removed, and that the demand for the products of Mr. Winsor's process will probably produce, in the course of a short time, a profit amounting to two millions per annum.

11. THAT your memorialists conceiving this to be a probable result, and extending their views to a consideration of the probability of a progressive extension of demand, as experience shall prove, that Mr. Winsor's light and heat may be obtained cheaper and better than any other description of fuel and light, entertain no doubt; that Mr. Winsor's process is eminently calculated to afford a liberal return to the company for the use of their capital, and at the same time to contribute in an essential degree to the improvement of the revenue, manufactures and general sources of national prosperity.

12. THAT your Majesty's memorialists now humbly beg leave to proceed to advert to the considerations which appear to them to recommend the prosecution of this discovery under the direction of a chartered company, as the best mode of management that can be adopted.

13. THAT your Majesty's memorialists most humbly resting upon these considerations, their claim to support their application to your Majesty for a charter, crave leave to enter upon a distinct examination of them in the order

in which they present themselves to their minds; and with this view your Majesty's memorialists will first enumerate the probable advantages of the management of this discovery being vested in a company by charter, and then proceed to state the probable effects of a failure in their humble endeavours to obtain a charter; in order that a just estimate may be formed of the relative proportion of public benefit to be expected in these respective events.

14. THAT your memorialists crave leave to submit to your Majesty that amidst the many advantages to be expected under the direction of a chartered Company, that such mode of management seems in the first place peculiarly well calculated to effect a speedy removal of the prejudices and difficulties to be encountered upon so novel an occasion; and consequently to facilitate the attainment of the important objects desired.

15. THAT your Majesty's memorialists, in further support of this mode of management, humbly apprehend that the superior advantages to be expected with respect to the amount of the revenue, as well as the facility of its collection, and the regard due to the popular feelings and prejudices, are considerations to which they may advert with propriety and effect.

16. THAT your Majesty's memorialists do not hesitate to admit that, with respect to revenue, both upon principles of strict justice and sound policy, that the products of Mr. Winsor's process are fit objects of taxation; and that the mode of levying a tax upon them should be calculated to afford a progressive increase, proportioned to the success of the Company, and the consequent defalcation of revenue which would ensue from a diminished consumption of other taxable commodities. But in the present state of information which your memorialists have been able to attain, it would be difficult to propose any direct taxes upon the products in question, that would not be liable to well-founded objections.

17. THAT your Majesty's memorialists crave leave to state that, on the one hand it might be contended by your Majesty's Government, that the taxes which might be proposed, were not adequate to the two-fold object of securing a fair equivalent for the eventual diminished produce of certain existing taxes, and make a participation in the probable advantages of the Company as the public would naturally expect.

18. THAT, on the other hand, it might be alleged by the shareholders, that at present no data could be assumed upon the basis of actual experience, for affording the desired contribution to the State; and that it would be equally injurious to the interest of the Company and the progressive increase of the revenue to burthen the concerns of the Company with any large drawbacks, in the way of duties, particularly in the infancy of its establishment.

19. THAT your Majesty's memorialists, to reconcile these opposite arguments, and to embrace the interest of both parties, on the one hand to afford a liberal participation of advantage to the State, and on the other hand to prevent the possibility of the concerns of the Company being burthened with duties to an extent exceeding what they would safely bear; and, in short, to afford the

largest possible scope for uniting all orders of the community in the bonds of one common interest, for one common object, viz., the diffusion of the advantages of Mr. Winsor's discovery to the utmost practicable extent ; we beg leave humbly to submit to your Majesty's consideration an offer to your Majesty's Government, as the basis of contribution, of a certain and liberal proportion of the actual net profits of the Company.

20. THAT your Majesty's memorialists humbly conceive that this offer must be considered as being at once simple, liberal, and safe. The actual contributions, to be paid by the Company, would be a net receipt into your Majesty's exchequer, and there would be no delay, trouble, or expense in its collection.

21. THAT your Majesty's memorialists, in addition to the considerations already stated, humbly beg leave to observe that, upon a just and comprehensive view of the subject, they conceive it will appear that the Government and the community are deeply interested in the success of the present application to your Majesty, as well as the intended Company ; since a large capital would be concentrated and employed by the Company in the prosecution of a discovery, promising not only the attainment of great advantages in the way of savings of expense in many of the public establishments (such as barracks, hospitals, &c., &c.), in all the various and numerous manufactories, and in the domestic economy of every householder in the realm ; but also, combined with these important advantages the establishment of a new source of revenue upon a plan susceptible of great and manifest improvement, and capable perhaps in the course of a few years of being carried to an extent which may enable your Majesty, in your parental regard for the community, to relieve it from some of the taxes now necessarily existing ; although unpopular in their nature, and, as connected with political economy, injurious in their effects.

22. THAT your Majesty's memorialists humbly beg leave also to observe that, coal being obtained, in this country, in greater abundance and of a better quality, than in any other part of the globe, it may be considered, almost exclusively, as a British product, and that as the coke, coal-tar, and ammoniacal liquor, to be drawn from coal by Mr. Winsor's process, may henceforth be afforded, both much cheaper and better than those articles have hitherto been sold, it may reasonably be expected that the demand for these will considerably increase, not only for home consumption, but also for exportation.

23. THAT your Majesty's memorialists humbly beg leave likewise to observe that, upon the whole quantity of these articles which may be exported, it seems practicable, in this particular case, to levy a tax, equal to the home duty, upon the foreign consumer ; since after payment of such tax they apprehend that the articles in question may be supplied from Great Britain much cheaper and better than they can possibly be procured by any other mode. This consideration your Majesty's memorialists most humbly and earnestly submit to your Majesty's most particular regard.

24. THAT your Majesty's memorialists humbly beg leave further to submit that your Majesty's Government cannot risk the loss of any revenue, by the adoption of the plan in the mode proposed ; because the existing branches of the revenue can only be affected in proportion to the success of the Company ; and consequently, if there should be a failure in any branch of the existing revenue, there must necessarily be a corresponding rise in the new revenue to be substituted in its stead, which, upon the liberal scale of contribution proposed on the part of the Company, would be more than adequate to a full equivalent.

25. THAT your Majesty's memorialists moreover humbly observe that, under the direction of a chartered Company, the benefit to be conferred by Mr. Winsor's discovery and the tax to be levied, would be introduced together, and no distinct views would be had of the tax, as it would be blended with the price of the article. That in this way the tax would not be felt at all. That the consumer would look only to his former and present expenditure, and finding, upon a balance, a considerable saving in his favour, notwithstanding the tax, he would consider himself relieved, and his situation improved, in proportion to the extent of such saving.

26. THAT your Majesty's memorialists having stated some of the principal advantages of the management of the discovery being vested in a company by charter, they shall now humbly proceed to offer to your Majesty's consideration the probable effects of a failure in their endeavours to obtain a charter.

27. THAT your Majesty's memorialists, in case of such failure, beg leave in the first place humbly to observe, that it is the intention of the contributors to the solicited company to dissolve themselves, and to divide the residue of their several subscriptions, after payment of the heavy expenses, which they shall have incurred, in experiments and in this application to your Majesty, since they have been advised that they cannot act with legality and effect without the sanction of a charter.

28. THAT your Majesty's memorialists beg humbly to represent that, in the event of such a dissolution of the contributors, Mr. Winsor would of course avail himself of his rights, under his present patent, of selling his stoves. That these stoves would thus, in course of time, be introduced into general use ; although in all probability by slow degrees. That certain existing branches of revenue must however decline in proportion to the introduction and operation of these stoves ; and that when this effect shall have been produced, the only way in which it seems practicable for your Majesty's Government to indemnify itself by taxing the products of the stoves, would be, by the application of the excise laws to this branch of revenue.

29. THAT you Majesty's memorialists humbly conceive that the collection of a duty so imposed would be attended with infinite trouble and expense ; while the extension of the excise laws to the domestic concerns of private families could not fail to be regarded with extreme pain by your Majesty's subjects, and a considerable portion of the people would perhaps determine

to forego the advantages of the discovery altogether, rather than submit themselves to the operation of those laws.

30. THAT your Majesty's memorialists humbly submit that, in such event, an increased consumption of other taxable commodities might indeed be expected to raise the produce of the taxes thence arising in due proportion to its former standard ; but the general benefits to be derived by the community would be greatly narrowed ; and the prospect of raising a large and progressive increase of revenue from the products of Mr. Winsor's discovery, would be extremely injured and perhaps totally lost.

31. THAT your Majesty's memorialists beg further to observe that, if failing in this their humble application to your Majesty, and the consequent sale as before supposed of Mr. Winsor's stoves should be established, the products of his process would be disposed of at their first introduction, without being subject to taxation ; and in such a case, any tax which might afterwards be imposed upon them would be felt as a tax to its full extent, and regarded in the same unpopular light as any other new description of impost.

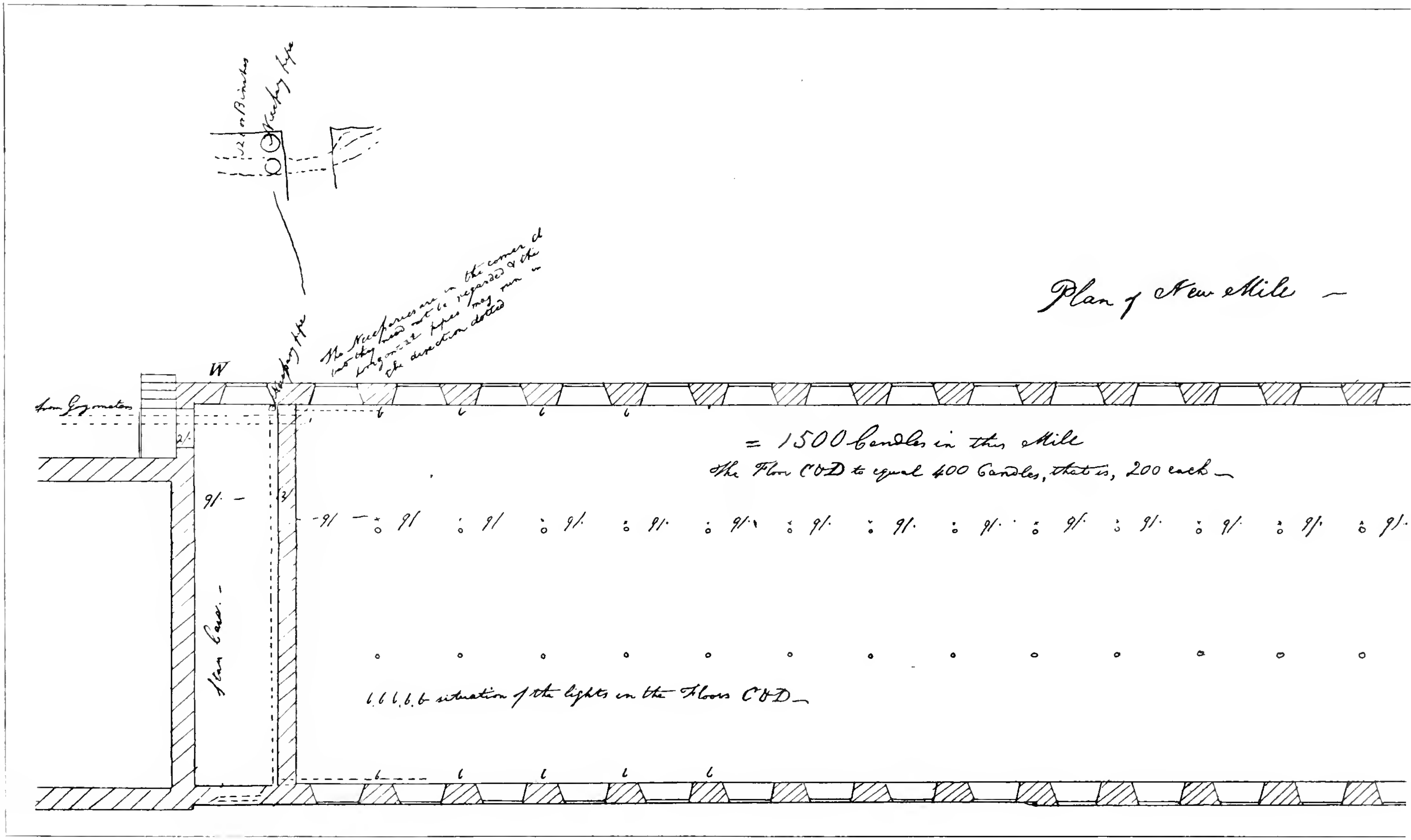
32. THAT your Majesty's memorialists, upon the foregoing view of the probable results in the respective events of the management of the discovery in question being vested in a company by charter, and of the failure of their humble endeavours to obtain a charter, combined with the further consideration that the most careful and unremitting attention, which can possibly be paid to the subject, will be requisite, for a series of years, in order to establish and mature the plan to that degree of perfection which it promises to attain, beg most humbly to submit to your Majesty, that the proposed mode of managing the business, and of levying a tax upon the products in question, through the medium of a chartered Company, is the best which under all the circumstances of this particular case can be devised.

Your memorialists therefore humbly pray your Majesty that your Majesty will graciously condescend to grant a charter of incorporation to your memorialists and others for establishing an institution to be called " the National Light and Heat Company " for the sole use of the oven, stove, furnace, or apparatus invented by the said Frederick Albert Winsor, and for making further experiments upon, and improvements in the same, and for vending and disposing of the several articles and substances to be produced by decomposition of fuel, and all other combustibles in the same, and for the exclusive enjoyment of all other benefits to arise therefrom, in such manner, under such rules, orders, and regulations, and subject to such duties and restrictions as to your Majesty shall seem fit.

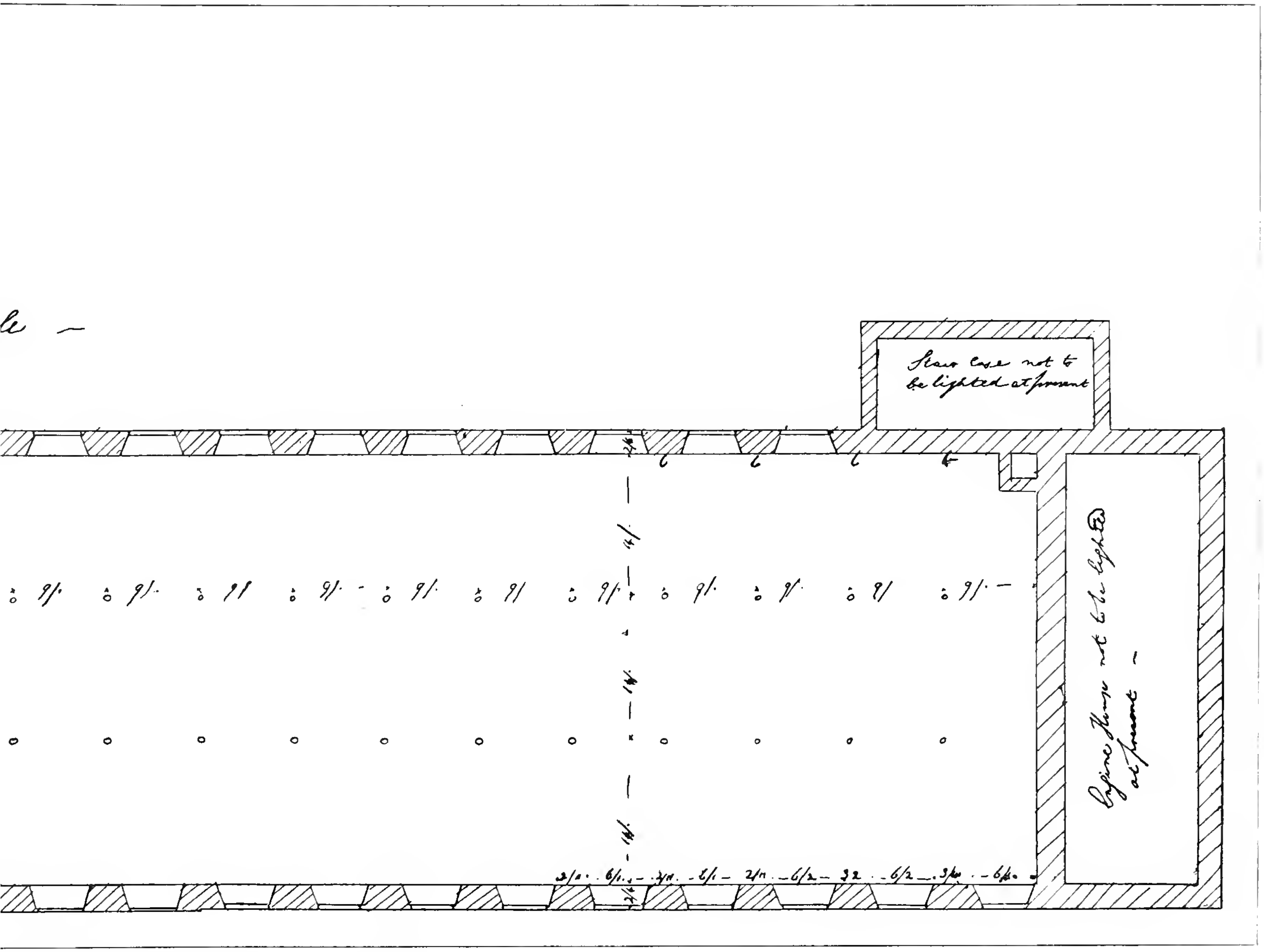
And your Majesty's memorialists will as in duty bound ever pray.

Signed, by the request of your Majesty's memorialists,

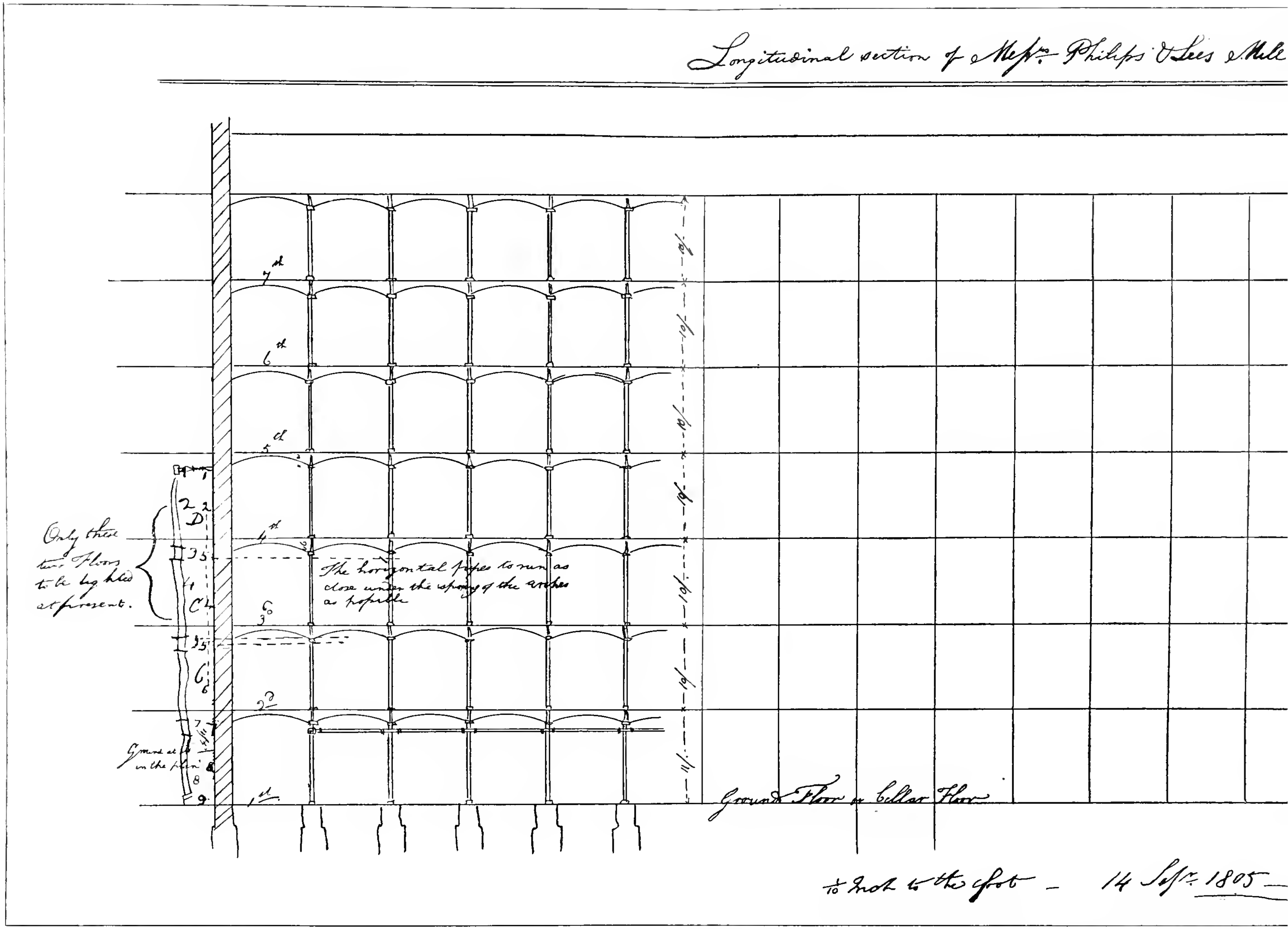
JAMES L. GRANT.


Plan of New Mill —
= 1500 Candles in this Mill
The Floor C&D to equal 400 Candles, that is, 200 each —
6.6.6.6.6 situation of the lights in the Floors C&D —
The Necessaries are in the corner & into they need not be regarded & the horizontal pipes may run in the direction dotted
Necessary pipe
Necessary pipe
1½ or 2 inches
from Gasometer
W
Stair Case —
9/-
2/-
3/-
6

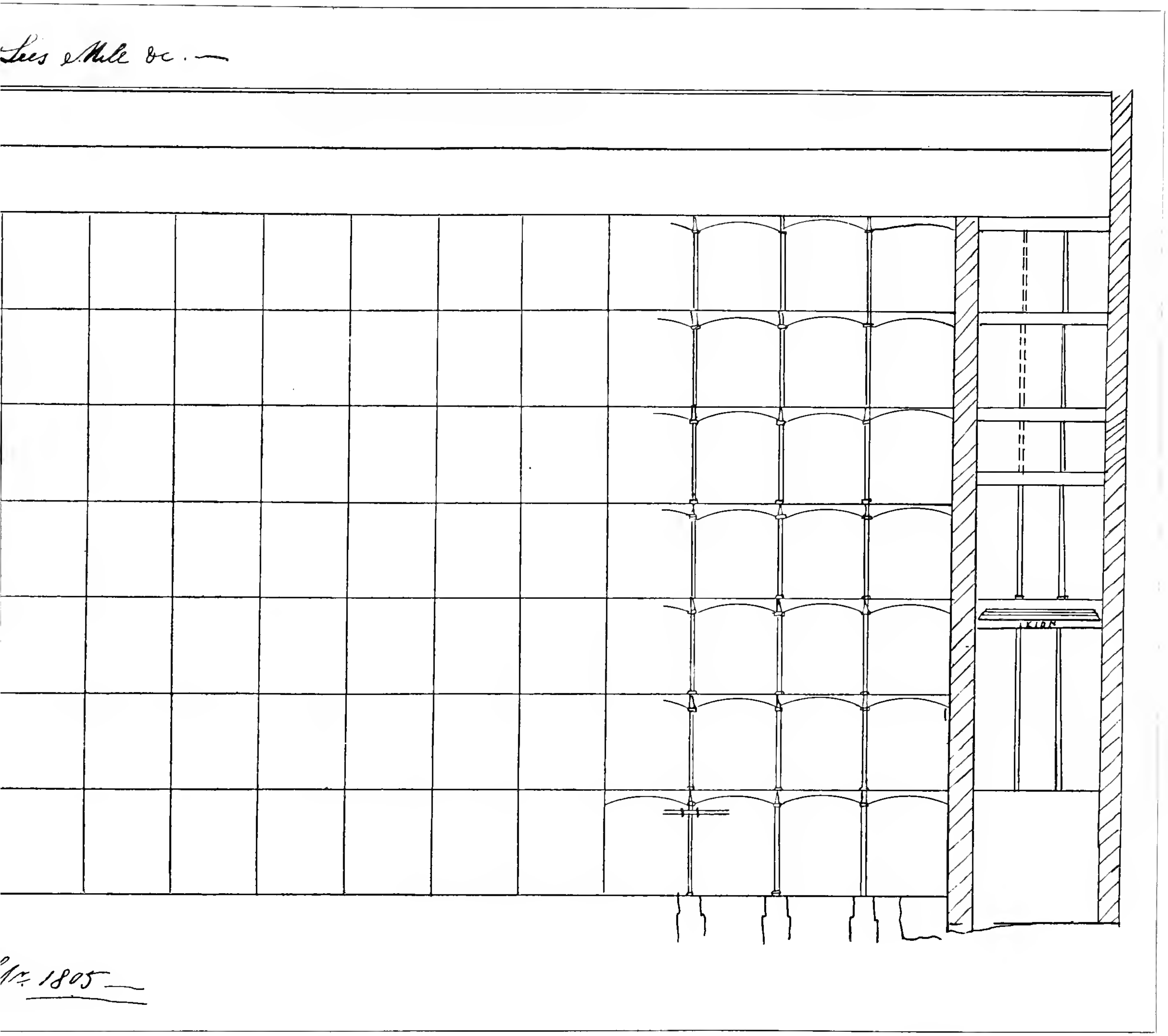
FACSIMILE OF ORIGINAL DRAWING OF MESSRS. PHILLIPS & LEE'S MILL, SHOWING PROPOSED LIGHTING


le –
Stair case not to be lighted at present
Engine House not to be lighted at present –
9/
4/
14/
14/
2/6
2/6

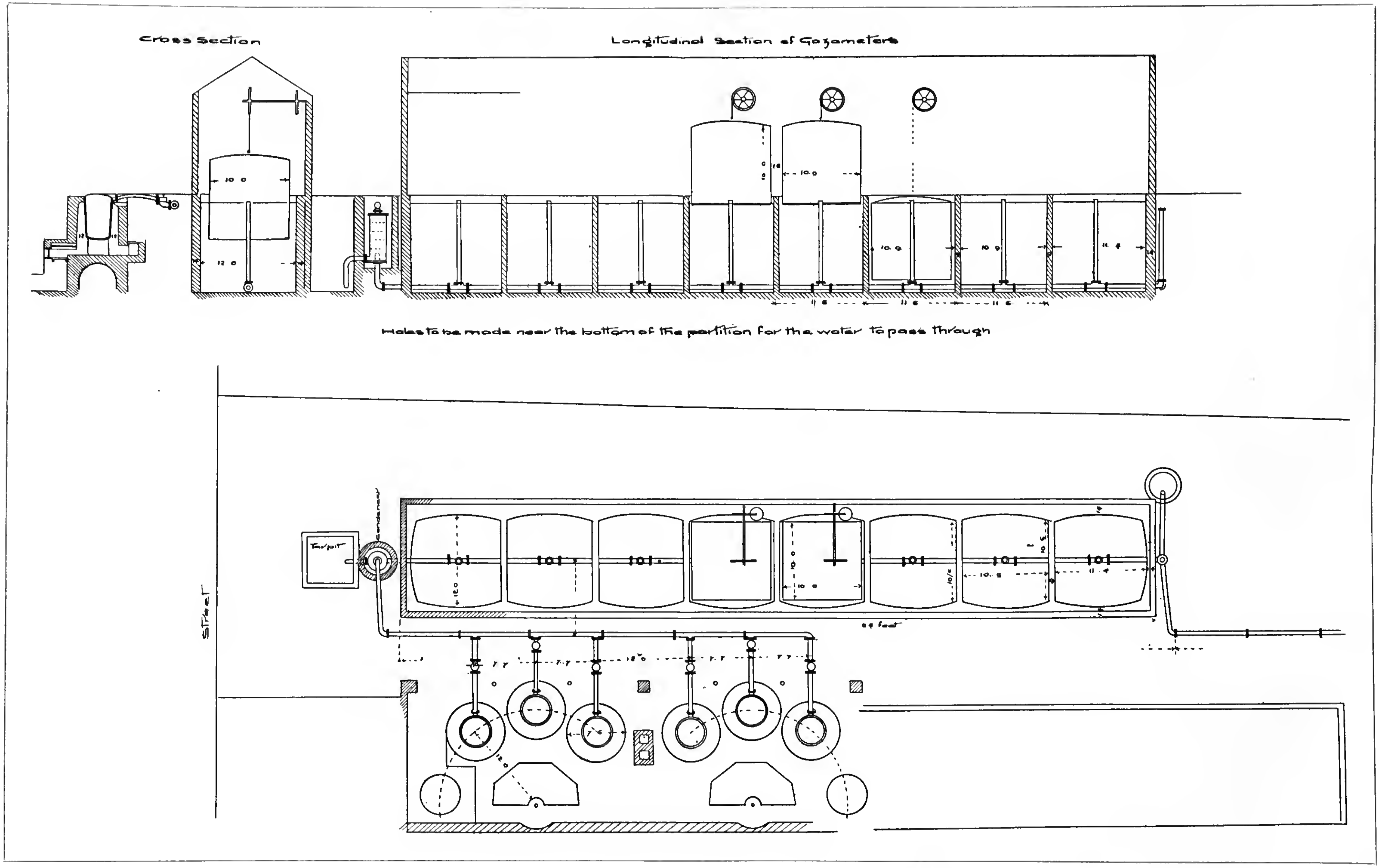
ROPOSED LIGHTING ARRANGEMENT. *Dated September 14, 1805.*


Longitudinal section of Messrs. Philips & Lees Mill
7th
6th
5th
4th
3d
2d
1st
10/.
10/.
10/.
10/.
10/.
10/.
11/.
Only these two Floors to be lighted at present.
The horizontal pipes to run as close under the spring of the arches as possible
Gmeine at in the plan
1
2 2
D
3 5
4
C 4
3 5
C 6
7
8
9
Ground Floor or Cellar Floor
1/10 Inch to the foot — 14 Sepr. 1805 —

FACSIMILE OF ORIGINAL DRAWING OF MESSRS. PHILLIPS & LEE'S COTTON MILL, SHOWING



MILL, SHOWING PROPOSED LIGHTING ARRANGEMENT.


Cross Section
Longitudinal Section of Gazometers
Holes to be made near the bottom of the partition for the water to pass through
Tarpit
Condenser
Street
64 feet

FROM THE ORIGINAL DRAWING OF MESSRS. PHILLIPS & LEE'S GAS WORKS. *Dated March* 5, 1806.

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